

# How Children Learn to Write Words 

REBECCA TREIMAN \& BRETT KESSLER


OXFORD

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## PREFACE

TThe goal of this book is to examine how children learn to use writing systems. To do so, we must understand the nature of writing systems themselves and the nature of human learning. Thus, after an introductory chapter, we include a chapter on each of these topics. In the chapters that follow, we discuss how children learn about various aspects of writing. We include chapters on the many things that are needed for correct use of a writing system, ranging from learning about the shapes of the symbols to learning about punctuation. In each chapter, we review and integrate research that has been done with learners of a variety of different writing systems.

This book draws from a number of research traditions, including linguistics, psychology, and education. Each field has its own terminology. We avoid specialized terms when possible. However, it is necessary or convenient to use some terms that will be unfamiliar to some readers. A term is defined the first time it is used, so looking up the term in the index will help you to find its definition.

We have kept the number of abbreviations and special symbols to a minimum. But the few abbreviatory devices and typographic conventions that we do use are employed repeatedly, so we invite you to familiarize yourself with the Symbols and Abbreviations section hereafter. The largest list there is that of symbols of the International Phonetic Alphabet, which are used to unambiguously indicate pronunciation in various languages. If you are familiar with the IPA, you may still find it useful to look over the list, because the examples illustrate how we apply the IPA to North American English. If you don't wish to memorize the IPA, the most important thing to know is that anything written between slashes // or square brackets [] is an IPA symbol, which you can look up as the need arises.

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SYMBOLS AND ABBREVIATIONS

## 1 Abbreviations

C consonant; for example, CC is a sequence of two consonants
IMP integration of multiple patterns
IPA International Phonetic Alphabet (International Phonetic Association, 1999)
V vowel; for example, CV is a consonant followed by a vowel

## 2 General Symbols

italics Italicized content is being mentioned, cited, defined, or referred to in running text: "It depends on what the meaning of the word is is."
sans serif Sans serif font is used to show that the content isn't from printed text. It usually implies that the content is handwriting.
<> Angled quotes enclose content that is being cited as characters of writing: "The word $a x$ is sometimes spelled «axe», but the child wrote «oxe»."
', Single quotes enclose meanings: "the Portuguese word avô 'grandfather'".
§2.3 The section symbol refers to sections in the book where a topic is discussed in more detail.
(I2) Numbers in parentheses refer to displayed examples. Numbering of examples starts with (1) in each chapter. References refer to examples in the same chapter unless otherwise stated.

## 3 Phonetic Symbols

When we cite words written in a script other than the Latin alphabet used for English, we add a pronunciation using an official or otherwise well-known romanization scheme for the language. When there is no well-known scheme, or when it is important to give precise descriptions of speech sounds, we use the IPA. IPA transcriptions are readily identified by the fact that they are enclosed in
slashes or square brackets. The following is an alphabetical list of the symbols we use. We give their technical definition and some example words that contain the sounds represented by the symbols. For most purposes, you should find the examples sufficient. Unless otherwise specified, example words are English and assume a General American pronunciation. Because phonemic transcriptions are somewhat simplified, the same symbol won't always represent exactly the same sound across all languages, but the sounds should be recognizably similar.

The technical definitions may also help you pronounce an unfamiliar sound and better follow some of our discussions of phonetics. Further information can be found in International Phonetic Association (1999).

The IPA symbols are defined in terms of the articulatory features of the sound they represent: how they are produced. Consonants are defined mainly by the place of articulation, manner of articulation, and voicing.

The place of articulation is where the tongue or lower lip moves in order to shape the sound:

| labial | the upper lip, as for $/ \mathrm{b} /, / \mathrm{m} /, / \mathrm{p} /$ |
| :--- | :--- |
| dental | the upper teeth, as for $/ \delta /$ and $/ \theta /$ |
| alveolar | the gums behind the upper teeth, as for $/ \mathrm{d} /, / / /, / \mathrm{n} /, / \mathrm{s} /, / \mathrm{t} /$, and $/ \mathrm{z} /$ |
| postalveolar | the roof of the mouth just behind the gums, as for $/ \overline{\mathrm{d}} /, / \mathrm{s} /, \overline{\mathrm{ts} /} /$, and $/ \mathrm{3} /$ |
| palatal | the hard palate, the bony part of the roof of the mouth, as for $/ \mathrm{j} /$ |
| velar | the soft palate, as for $/ \mathrm{g} /, / \mathrm{k} /$, and $/ \mathrm{y} /$ |
| pharyngeal | the throat |
| glottal | the vocal folds (also called vocal cords) in the larynx, as for $/ \mathrm{h} /$ |

Place of articulation can be described in more detail by also describing what the lower lip or tongue is doing:
bilabial lower lip approaches upper lip, as for $/ \mathrm{b} /, / \mathrm{m} / \mathrm{/} / \mathrm{p} /$
labiodental lower lip approaches upper teeth, as for /f/, /v/
retroflex the tongue is curled back
Manner of articulation describes how the tongue or lip interferes with the flow of air.
plosive a complete blockage, resulting in a little burst of noise when released, as for /b/, /d/, /g/, /k/, /p/, and /t/
nasal air is completely blocked in the mouth, but escapes through the nose, as for $/ \mathrm{m} /, / \mathrm{n} /$, and $/ \mathrm{n} /$
fricative air is highly restricted in the mouth, causing a turbulent noise, as for /ठ/, /f/, /s/, / / /, /v/, /z/, /3/, and / $\theta /$
affricate a plosive that is released gradually, resulting in a fricative-like noise rather than a burst, as for $/ \overline{\mathrm{d} 3} /$ and $/ \overline{\mathrm{t} \oint} /$ (see also $\int_{2 \text { 2.2.2.3 }}$ ).
approximant the airflow isn't blocked enough to make any noise, as for $/ \mathrm{j} / \mathrm{I}, \mathrm{l} / \mathrm{I} / \mathrm{x} /$, and /w/

When producing lateral sounds such as $/ 1 /$, the air flows around the sides of the tongue.

Voicing describes whether the vocal folds are vibrating, resulting in the buzzing sound called voice. Most sounds are voiced, but some sounds are voiceless, as /f/, /k/, $/ \mathrm{p} /, / \mathrm{s} /, / \mathrm{S} /, / \mathrm{t} /$, $/ \overline{\mathrm{t}} /$, and $/ \theta /$.

Vowels don't block the airflow at all. They are defined in terms of how far the body of the tongue moves in two dimensions. Open vowels (also called low vowels), such as /a/ and /æ/, are pronounced with the tongue low in the mouth; close vowels (also called high vowels), such as $/ \mathrm{i} /, / \mathrm{I} /, / \mathrm{u} /$, and $/ \mathrm{v} /$, are pronounced with the tongue high in the mouth; mid vowels, such as $/ \partial /$, are pronounced with the tongue elevated halfway. Intermediate degrees of openness can be expressed by compound terms such as open-mid, for $/ \varepsilon$ / and $/ \mathrm{J} /$, or close-mid, for $/ \mathrm{e} /$ and $/ \mathrm{o} /$. The second dimension is how far the body of the tongue moves forward or backward. Front vowels place the tongue body near the hard palate (/æ/, /e/, / $\varepsilon /$, $/ \mathrm{i} /$, and $/ \mathrm{I} /$ ); back vowels place it closer to the soft palate or the throat (/a/, / $/$ / $/ \mathrm{J} /, / \mathrm{u} /$, and $/ \mathrm{v} /$ ); a central vowel like $/ \mathrm{\partial} /$ is halfway between. A lax vowel is pronounced with the tongue relaxed more toward the mid-central position than comparable vowels. The vowel / $\mathrm{I} /$ is a lax version of $/ \mathrm{i} /$, and $/ \mathrm{v} /$ is a lax version of $/ \mathrm{u} /$. Certain vowels are further characterized by being pronounced with rounded lips (/ $\mathrm{o} /$, $/ \mathrm{J} /, / \mathrm{u} /$, and $/ \mathrm{v} /$ ) or by being nasalized, allowing air to flow through the nose.

Vowels are usually the most prominent part, or nucleus, of a syllable. Consonants are relegated to the onset or coda of a syllable-the positions before or after the nucleus. It is also possible for a consonant to form the nucleus, which is indicated in IPA by a vertical line under the consonant letter: apple /æpl/.
/ / Slashes enclose pronunciations in IPA, in a broad transcription: "English cat $/ \mathrm{kæt} /$ ". The elements in such a transcription represent phonemes, sounds that are represented only at the level of detail required to distinguish between words in a particular language ( $(\mathbb{2} 2.2 .2 .3)$.
[ ] Square brackets enclose pronunciations in IPA: "English cat starts with a [k $\mathrm{k}^{\mathrm{h}}$." The elements in such a transcription represent phones, that is, individual segments of speech ( $\$ 2$ 2.2.2.3). We use this notation in contexts where we aren't referring to phonemes in a particular language or when the level of phonetic detail is more specific than that required for phonemic transcription.
a open unrounded vowel: ont/aut/, aisle /ail/, Spanish paso /'paso/ 'step'
$\boldsymbol{æ} \quad$ raised front open unrounded vowel, with the tongue raised a little higher than for /a/: apple /'æpl/
a back open unrounded vowel: father /'faðər/
$\boldsymbol{\Lambda}$ back open-mid unrounded vowel: An old-fashioned pronunciation in butter /'bıtə/
b voiced labial plosive: $\underline{\operatorname{big}}$ /big/
c voiceless palatal plosive: Irish céad /ce:d/ 'first'
d voiced alveolar plosive: $\underline{d} 0 \mathrm{~g} / \mathrm{dag} /$. Often a tap in American English: kitty / kıdi/ ['k ${ }^{\mathrm{h}}{ }^{\text {rifi] }}$

d voiced retroflex plosive: Swedish bord [bu:d] 'table'

б voiced dental fricative: this / J Is/
e front close-mid unrounded vowel: ape /ep/
ə central mid vowel: $\underline{a b o v e} /$ /ə'bəv/
$\boldsymbol{\gamma}^{\boldsymbol{r}} \quad$ another representation of $/ \boldsymbol{\downarrow} /: / \mathrm{x} /$ used as a syllable nucleus: bird $/ \mathrm{b} \boldsymbol{\mathrm { d }}$ /
$\boldsymbol{\varepsilon}$ front open-mid unrounded vowel: edit /'عdit/
f voiceless labiodental fricative: fine /fan/
g voiced velar plosive: go /go/
h glottal fricative: happy /'hæpi/
h
aspirated: followed by a puff of air that continues the voicelessness of the plosive into the next phone: $\underline{c a t}$ [ $\mathrm{k}^{\mathrm{h}} æ \mathrm{t}$ ]
i front close unrounded vowel: marine /mə'rin/
I lax front close unrounded vowel: $i \underline{i t c h} / \widehat{\mathrm{it} 5 /}$
j palatal approximant: $\operatorname{yes} / \mathrm{j}$ zs/
$\mathbf{k} \quad$ voiceless velar plosive: $\underline{\text { kid } / \mathrm{krd} / ~}$
1 alveolar lateral approximant: look /luk/
m labial nasal: moon /mun/
n alveolar nasal: ñow /nav/
y velar nasal: sing /siy/
o back close-mid rounded vowel: over /'ova/
$\boldsymbol{\jmath}$ back open-mid rounded vowel: all /ol/; boy /bor/
p voiceless labial plosive: pay/pe/
r alveolar trill: Spanish río /'rio/ 'river'. We also use this symbol when a language has an [r]-like sound but its exact articulation isn't important to the discussion.
J postalveolar approximant: read/xid/
r alveolar tap: butter ['bərə], Spanish cara /'kara/ 'face'
в uvular approximant: French Paris /раві/
s voiceless alveolar fricative: sound /saund/
s voiceless retroflex fricative: Swedish färsk [fæsk] 'fresh'
$\int$ voiceless postalveolar fricative: sheep / Sip /
t voiceless alveolar plosive: toy /toI/
$\overline{\mathbf{t} \boldsymbol{J}} \quad$ voiceless postalveolar affricate: teach $/ \mathrm{tit} \overline{\mathrm{J}} /$
t voiceless retroflex plosive: Swedish karta [ $\mathrm{k}^{\mathrm{h}} \mathrm{a}: \mathrm{ta}$ ] 'map'
u back close rounded vowel: $r \underline{u} d e /$ sud/
u lax back close rounded vowel: pull /pul/
v voiced labiodental fricative: $\underline{v a t}$ /væt/
w /u/ used in a syllable onset: weed /wid/
x voiceless velar fricative: German Buch /bu:x/ 'book'
$\mathbf{z}$ voiced alveolar fricative: $\underline{z o o} / \mathrm{zu} /$
3 voiced postalveolar fricative: measure /'m\&3 $3 \% /$
$\boldsymbol{\beta} \quad$ voiced bilabial fricative: Ewe Ève /èße/ 'Ewe'
$\boldsymbol{\theta}$ voiceless dental fricative: think / $\theta \mathrm{mg} /$
? glottal stop: Arabic $\mathfrak{i}$ as in /Risla:m/ 'Islām'
§ voiced pharyngeal fricative: Arabic $\varepsilon$ as in /fi:d/ 'feast'

- The tie connects two characters that together represent a single phone; e.g., /t $/$ /, / $\overline{\mathrm{d}_{3}} /$
~ A tilde over a letter means the sound is nasalized: French bon /bõ/ 'good'
- An acute accent over a letter means the sound is pronounced with a high tone. That is, the pitch of the voice is elevated ( $(\mathbb{2} 2.2 .2 .2)$.

A grave accent over a letter means the sound is pronounced with a low tone. That is, the pitch of the voice is lowered.

A vertical bar under a letter means that the sound is a syllabic consonant, that is, one that appears as the nucleus of a syllable, in place of a vowel: apple ['æpl].
A downward tack under a fricative letter means the sound is pronounced weaker, as an approximant: Spanish pueblo ['pweßlo] 'people'

- The following syllable is stressed: believe /ba'liv/
: The preceding phone is longer than a comparable basic phone: Italian nonna /'non:a/ 'grandmother'

J, 1 The preceding syllable is pronounced with a low, falling tone, a fairly high tone, etc. The line to the left of the vertical staff iconically shows the relative height and contour of the pitch of the voice.

## CHAPTER 1 <br> Introduction

hUMANS HAVE A REMARKABLY powerful means of communication: language. Human language allows people to communicate virtually any type of thought: a current perception, a memory, a new idea. Language has permitted people to cooperate in creative ventures to an unprecedented degree, and it is one of the most important foundation stones of human culture. Language, however, has a serious shortcoming: It is naturally evanescent. A sentence lives on only in the (imperfect) memory of those who hear it spoken or, in the case of a signed language, those who see it signed. Without special technology, one can use language to communicate with someone who is nearby but not with someone who is in the next town or the next century. To overcome these limitations of space and time, humans have worked out other methods of communication, ones that are designed to last. These permanent communication systems, which are often visual, allow people to convey information and ideas to those who are remote in time and space. They vastly increase the range over which people can cooperate.

The system of permanent communication that we discuss in this book, writing, is much younger than spoken language. While spoken human language must have been around for at least 50,000 years, the earliest writing is only about 5,000 years old. Despite its relative youth, writing has been vitally important because it allows people to learn about things that they haven't directly experienced and because it allows information to be preserved for long periods of time. In modern societies, people gain much of their knowledge about the world through writing rather than through direct personal experience. Indeed, it has been said that "humankind is defined by language; but civilization is defined by writing" (Daniels, 1996, p. 1).

Our goal in this book is to examine what types of writing systems exist in modern societies and how children learn to use these systems for purposes of production. We discuss how children learn about such things as the shapes and names of letters, the spelling of individual words, and
capitalization and punctuation. These are all part of orthography, the correct way of using a writing system to write a language. To set the stage, we begin this introductory chapter by discussing writing as one of many tools that people have developed. We discuss the need to master such things as spelling and punctuation in order to make effective use of the tool, and we introduce some of the controversies about how such mastery is achieved. We consider how the learning and use of orthography have been studied in the past, and we preview the approach that we will take in the remainder of this book.

### 1.1 Writing as a Tool

Writing is one of many tools that people have developed to circumvent their natural limitations. To understand the nature of writing, and to understand how children learn to produce it, it is helpful to view writing within the framework of tools more generally.

Some of the limitations that motivate the development of tools reflect people's physical characteristics and those of the environment. For example, feet can take us a certain distance in a day, but no further. Our metabolism can keep us comfortable at moderate temperatures, but not at extremes. Fortunately, evolution has equipped people with the ability to invent and use tools. People have developed cars and warm fabrics, among other things, in an attempt to overcome their physical limitations.

People have cognitive limitations as well as physical ones. Despite a common belief, it is not true that human memory is like a video recorder. According to that view, people would take in detailed information about each event they experience. They would record one event as easily as another, storing it in memory like a video clip. They would later replay the stored information "as it echoes in the mind's ear or flashes in the mind's eye" (Brainerd, Wright, Reyna, \& Payne, 2002, p. 121). However, psychologists now understand that the human mind doesn't usually work this way. Limitations in perception and attention mean that people don't take in everything that occurs around them. Limitations in memory mean that some information isn't stored and that what is stored fades over time. People can hold just a small number of items at one time in short-term memory, the part of memory that retains information that is currently active. Information in this memory store decays quickly, in around 30 seconds or so, unless special steps are taken to prolong it. These limitations make it difficult to do such things as add a long series of numbers in one's head. People can store a great deal of material in long-term memory, the part of memory that retains information over long periods of time, even indefinitely. However, it takes effort to get things into and out of this vast store. Some things tend to be remembered well, such as information that is personally relevant or the meaning of what someone said. Other things tend to be remembered poorly, such as the
exact words that were used to do so. Someone may be temporarily unable to retrieve a piece of information from long-term memory, such as a word that she doesn't use very often.

People have developed various tools in an attempt to circumvent their cognitive limitations. Some cognitive tools, such as calculators and abaci, are outside the body but may become, in some ways, extensions of it. Other cognitive tools, such as remembering a list of things by the mnemonic method of associating each one with a place on one's daily walk to work, are internal. When a person writes down a list of numbers that he wants to add, his friend's address, or the words that someone said, he is using an external tool in an attempt to circumvent his internal cognitive limitations. When he imagines the spelling of a word, he is internalizing a tool.

Tools allow people to do certain things more economically than they otherwise could, and they often improve the quality of the result. Indeed, some tools allow people to do things that would otherwise be impossible. For these reasons, individuals and societies are willing to put in the time and effort needed to develop, learn about, and use tools. It's easy to learn to use a television remote control device, and it saves one from getting off the couch to change the channel. Writing is harder to learn, but the effort returns much more. When a tool is difficult to learn and use, additional tools may be developed as aids, such as dictionaries in the case of writing.

The design, learning, and use of tools are influenced by people's tendency to satisfice (from a blend of satisfy and suffice; Simon, 1957): to do the least they can in order to attain what they consider to be a satisfactory result. Achieving perfection often requires a good deal of time and effort, and people are often willing to accept a less than perfect result if it is easier or quicker. Thus, economy is a strong influence on human behavior. Economy may be fostered in a various ways. For example, production often becomes easier and quicker when movements overlap or blend.

The tools that people invent are influenced by their abilities and limitations, even as they are designed to overcome the latter. For example, the button on a remote control device for a television is designed so that a human thumb or finger can easily depress it. Writing is the way it is, in part, because people invented it and must learn to use it. A computer could handle a writing system in which each word was represented with a unique and detailed shape, the shape for snow being quite different from the shapes for snows and snowman. However, children would have great difficulty learning and using such a system.

The nature of a tool depends on what results people consider satisfactory. If it is satisfactory to have a general idea of the time, a sundial will suffice. If a high degree of precision is required, an atomic clock may be needed. Scriptio continua, a method of writing that uses only letters but no spaces or punctuation (1), is satisfactory if people expect to have to study and annotate a text before reading it aloud. If people expect to be able to read unfamiliar texts quickly and easily, as they do nowadays, scriptio continua no longer suffices.

Punctuation and word spacing demand effort from writers and aren't always strictly necessary; (1) has only one reasonable interpretation. But the spaces that appear between words in many writing systems provide additional cues that benefit readers.

## (1) BEFOREAD1000ITWASCOMMONTOLEAVENOSPACES BETWEENWORDS

In judging whether an outcome is satisfactory, people tend to consider the present rather than the future. For example, one can sometimes achieve a satisfactory result with a computer program by using a series of familiar commands rather than a more efficient but unfamiliar command, or by asking one's spouse or colleague for help. A computer user may therefore be reluctant to learn another method that, although difficult at first, would save time in the long run. This means that even experienced users of certain computer tools may routinely use inefficient procedures (Bhavnani \& John, 2000). Such phenomena, together with the common observation that people sometimes postpone medical tests and dental appointments, show that people find it difficult to discount local rewards in favor of greater global ones. As we will see, these things affect the learning of writing.

What is satisfactory for the tool maker and what is satisfactory for the tool user don't always agree. Ease of use trumps ease of manufacture when many people use a tool but few must make it. This is the case for an abacus or a television remote control device. With other tools, including writing in the case of modern societies, people expect to be able to produce the tool themselves. The needs of writers and readers aren't identical, and writing systems must balance the two.

Those who are learning about a tool and those who are experts in its use may also have different needs. For example, a beginner may find it easy to use a computer program that depends on selecting from functions displayed on the screen, but having to call up menus may impede an expert. With writing systems, too, there are trade-offs between the needs of learners and experts. Learners' needs are especially important in many societies that value mass literacy. Korean used to be written with Chinese characters, a system that could take many years to master. But an emerging belief in the 1400 s that literacy should not just be the domain of the educated male elite led to the development of an alphabetic writing system that could be learned quickly. This system, hangeul, opened up literacy to women and to all classes, but it encountered opposition from the educated elite who were already expert in the use of Chinese characters.

Tools are invented to serve particular functions: facilitating movement in the case of wheels or freezing language in the case of writing. Even though a tool is a means to an end, people want it to be attractive as well as useful. Thus, they may make the effort to decorate a tool even when decoration doesn't enhance its function. A pot with designs carved on it cooks no better than a pot
without, but people prefer it because it is attractive. The designs may identify the owner as a member of a particular social group or may express his individual tastes. Writing, like other tools, has been shaped by people's desires for beauty and expression.

The availability of a cognitive tool means that people don't have to do certain things on their own. For example, calculators mean that people don't have to add and multiply in their heads, and paper or computer calendars mean that they don't have to store the time of a meeting in their own memories. When a new cognitive tool is introduced, debates often arise about whether people will get dumber if they use it. What will they do if a tool is temporarily unavailable, as when a cash register breaks and a cashier can no longer make change? Similar debates arise in the case of writing. Before writing was invented, certain important texts existed only in the minds of learned people who preserved that knowledge in their excellent memories. Some Greek thinkers, including Socrates, feared that people would become less intelligent when they wrote, because their memories would atrophy. That doesn't seem to have happened, but it is true that people sometimes use writing as a form of external storage rather than storing information in their own memories (Eskritt, Lee, \& Donald, 2001).

Learning to use the tools of a society in the agreed-upon way is an important part of becoming a full member of that society, and children are highly motivated to do so. When a tool is widely used, children see many examples of it from an early age. They see the actions that experienced tool users perform, and they see the results that ensue. Transmission of tool use from one generation to the next is facilitated by children's tendency to observe and imitate the purposeful actions of experienced others, especially others from their own social group. So strong is children's drive to do this that they may even reproduce actions that yield no obvious or interesting results, whose functions they don't understand, or that have been demonstrated to other people rather than to the children themselves (Lyons, Young, \& Keil, 2007; Nielsen, Moore, \& Mohamedally, 2012; Yang, Sidman, \& Bushnell, 2010). Thus, young children who see adults or older children write may try to reproduce the movements and the results. They start learning about some of the formal properties of writing-what it looks like-before they know much about how writing functions to symbolize language.

Transmission of tool use from one generation to the next is facilitated not only by children's drive to fit in but also by adults' tendency to demonstrate and explain (Csibra \& Gergely, 2009). Adults may consciously or unconsciously modify their tool use in an attempt to help children learn about the tool. They may signal that an action is intended for children to imitate, they may take steps to ensure that children attend to the action, or they may perform an action in a repetitive or exaggerated way (Brand, Baldwin, \& Ashburn, 2002). And adults may explain to children what they are doing and why. Their language may highlight distinctions that are difficult to glean from observation or convey generalizations that go beyond particular instances. Adults expect
children to learn to use tools in the culturally prescribed manner, and they may verbally or nonverbally correct children who don't conform.

Transmission of tool use from adults to children is also facilitated by the fact that young children, who have so much to learn, tend to think that adults know everything. Understanding why the sky is blue is difficult enough that an advanced student of physics may be asked to explain this on an exam. Six-year-olds, however, generally think that their parents understand such things.

Tools are shared by members of particular groups. A child who knows that the members of a group have the same conventions about tool use can learn from any experienced tool user in the group. The child need not learn new facts for each person. For example, a child who hears his mother refer to the shape V as /vi/ can assume that his father and his aunt call it /vi/ too. (See Introduction, "Symbols and Abbreviations," 3, for a key to the phonetic symbols.)

Learning about a tool allows a child to use it, but it may have broader effects as well. This happens because tools aren't neutral; they have their affordances and their constraints. For example, two-dimensional maps distort curved surfaces. This can lead to distortions in thinking, such as thinking that Greenland is larger than Africa because of how it appears on most maps. But maps help people, too; for example, by helping them to understand the spatial relations among parts of a city that they may not have noticed before. Similarly, learning a writing system helps children to understand some aspects of language; for example, that a continuous string of speech can be conceptualized a series of smaller units. At the same time, the tool promotes certain fictions, such as the idea that the latter portion of spit sounds exactly like pit. It doesn't. If the /s/ of spit is removed from an audio clip, the remainder sounds like bit.

### 1.2 Orthographic Knowledge as a Part of Writing

People write to record their ideas, to share them with others, and to search for information, as in a catalog or on the Web. Everyone agrees that children should learn to do these things in order to participate fully in a modern society. But how important is it to learn the details of spelling, punctuation, and handwriting? For example, if a computer search engine will find information on ptarmigans when a child types <tarmigan», must the child learn to produce the conventional spelling? Some people believe that, just as the invention of writing freed people from some of the constraints of spoken language, so the invention of spelling checkers and grammar checkers frees them from the need to learn about the details of orthography. As one teacher said, "My kids don't need to worry about correct spelling, because they can get the right spelling by using the spell-checkers on the computer" (Graham, Harris, \& Fink Chorzempa, 2002, p. 683). Consistent with this view, researchers and educators sometimes call spelling a low-level skill. This is often understood as
implying that it is not important in its own right, but is subservient to the high-level skills that are involved in composing well-constructed texts.

### 1.2.1 Cognitive Resources and Technical Tools

Knowledge of orthography is still important in the age of spell-checkers, in part because people's mental resources are limited. When a cognitive task requires many resources-when it isn't what cognitive psychologists call auto-matic-fewer resources are available for other tasks. Thus, children who must devote a good deal of effort to spelling, punctuation, and letter formation have fewer mental resources available for other aspects of writing. Seven-year-olds can tell a pretty good story, but the stories that they write tend to be shorter and less diverse in vocabulary than their oral narratives (Howell, 1956). Writers of this age may "become discouraged and fatigued when they cannot spell many of the words they want to use and when they find it difficult to print those they do know how to spell" (Howell, 1956, p. 145). As handwriting and spelling become easier, children can pay more attention to planning and organization. By 8 to 10 years of age, children's handwritten narratives are as cohesive and well formed as their oral ones, though still shorter (Hidi \& Hildyard, 1983). Although handwriting may be fairly automatic by this age, other methods of text production may not be. In one study, 10 - and 11-year-olds who had little keyboarding experience wrote poorer quality essays when using a computer keyboard than when writing by hand (Connelly, Gee, \& Walsh, 2007). Teenagers and university students who are experienced with keyboarding don't produce poorer quality texts when using a computer than when writing by hand (Kellogg, 2001; Owston, Murphy, \& Wideman, 1991). However, university students produce poor-quality texts when they are asked to use uppercase cursive script, a relatively unfamiliar hand, than when they use their normal handwriting (Olive, Alves, \& Castro, 2009; Olive \& Kellogg, 2002). At any age, therefore, a lack of skill with the mechanics of writing can hurt the quality of the result.

Tools exist that can help with spelling, including dictionaries and spell-checkers. However, tools can't help people who don't use them. Dictionary use, in particular, takes time and effort. In one study, locating a word in a children's printed dictionary took over 45 seconds on average for English 8 -year-olds and around 30 seconds for 10 -year-olds. Even when a word was in the dictionary, children sometimes failed to find it (Beech, 2004). Additional time and effort are required for children to read a definition in order to make sure that they have located the intended word rather than, for example, another word that sounds the same. Children need time, too, to copy the correct spelling into the text that they are writing. Given the effort that is required to use dictionaries, it isn't surprising that children often avoid them. For example, the 8- to 10 -year-old English children in one study reported that they used a dictionary only around once a week (Beech, 2004). In another study, French children of similar ages often didn't use a dictionary when it was put in front
of them, even though they produced fewer spelling errors when they used the dictionary than when they didn't (Lemaire \& Lecacheur, 2002). Children avoid dictionaries, in part, because they are often overconfident about their spelling (Tidyman, 1924). A child who thinks that he can spell a word correctly probably won't take the time to look it up in a dictionary.

The computerized spell-checkers in word processing programs and search engines usually work automatically and without being asked. They deal with all of the words in a text, and they do so quickly. Given these advantages, it isn't surprising that teenagers and young adults spell more accurately when they have access to a computerized spell-checker than when they have access only to a dictionary. With a spell-checker, too, students are more likely to detect and correct spelling errors when revising a text (Figueredo \& Varnhagen, 2006; Owston et al., 1991).

Errors can occur even with the help of computerized spelling checkers, though. Around $25 \%-40 \%$ of the errors that English-speaking teenagers and adults produce when writing texts are real words (Kukich, 1992). Many spell-checkers don't flag such errors, although spell-checkers that consider context detect some of them. Because people tend to overlook errors that are real words when they proofread their own work (Daneman \& Stainton, 1993), the fact that spell-checkers don't eliminate them is a concern.

The spell-checkers in word processing programs often present a list of alternatives when they detect an error. Problems can arise when the user fails to recognize and select the correct spelling. Ideally, the list of alternatives should be short and the correct spelling of the intended word should be at the top of the list. When misspellings in the compositions of British 14 -year-olds were submitted to the 1995 versions of two popular spell-checkers, this was true only $30 \%$ of the time for one spell-checker and $17 \%$ for another (Mitton, 1996). The outcome was better when the 2000 version of a popular Dutch spell-checker was tested on the productions of 8-year-olds (Bosman, van Huygevoort, Bakker, \& Verhoeven, 2007). However, the spell-checker performed poorly when children attempted to write words such as jus 'gravy' that came into Dutch from other languages and that retained their original spellings-no small problem given that such words constitute about $15 \%$ of the Dutch vocabulary. People's tendency to choose the alternative that a spell-checker lists first, even when it is wrong, has been called the Cupertino effect (Zimmer, 2006), because a surprising number of official documents contain the name of that California city in place of the word cooperation (2):
(2) Could you tell us how far such policy can go under the euro zone, and specifically where the limits of this Cupertino would be?

This incomprehensible sentence arose because a spell-checker that contained only the hyphenated form «co-operation» suggested <Cupertino» as its first correction. Problems can also arise with spell-checkers that work automatically, correcting what they consider to be mistakes without the writer's
intervention. And even the best technology currently available would have trouble coping with spellings of young children that are far off the mark, including «FURLVDKITRH〉, one US child's rendition of "If you are looking for the key it is right here" (Dyson, 1991). The limitations of spell-checkers help to explain why, in studies of search engine use, children take longer to find information about difficult-to-spell terms such as ptarmigan than about easier ones and why the search for information is less likely to succeed in the former case (Varnhagen et al., 2009).

### 1.2.2 Social Implications of Nonstandard Spelling

What level of orthographic knowledge do writers need in order to convey their ideas? Perhaps the ability to produce plausible spellings suffices, even if the spellings aren't fully correct, the letters are poorly formed, and punctuation and capitalization are missing. According to this view, a child who produces <if $u$ ar lookin for the kee it is rite heer> is doing just fine. Truly intelligent people have freed themselves from unimportant conventions; as the old saw has it, "It is a damn poor mind that can only think of one way to spell a word" (Curtis, 2002, p. 54).

Yet, just as table manners involve more than arbitrary rules about which fork to use first at a formal dinner, so orthography involves more than arbitrary facts. Both table manners and orthography are sets of conventions that allow for easy and comfortable interactions. We are reminded of a debate that took place at a nursery school. The teacher, a rather informal sort, suggested that the 3 -year-olds be allowed to pick up their midmorning snack from a table during breaks from play. The parents disagreed. Sitting together at a table, they said, asking one's classmate to pass the crackers rather than grabbing them oneself, isn't a meaningless convention. It promotes unity and consideration for others. Similarly, spelling words in an agreed-upon and neat way, not however one feels like at the moment, fosters successful communication. For example, mistyping hair as «hare> in the phrase "she has blonde hare" caused people to read more slowly than they otherwise would (Daneman \& Reingold, 1993; Treiman, Freyd, \& Baron, 1983). Omitting or misusing punctuation can also cause difficulty for readers. A sentence such as "Because Jay always jogs a mile seems like a short distance to him" is susceptible to misinterpretation or lots of backtracking (Frazier \& Rayner, 1982); a simple comma after jogs eases readers' task (Hill \& Murray, 2000). Conventions are beneficial even in informal situations where people innovate in spelling. For example, one group of people who communicate with one another on social media may write «koo» for cool, and another group may use <coo>. Conventions develop with written language, as in other areas of human interaction, because they help that interaction to succeed.

Because most people feel that it is important to follow the conventions of their society, in orthography as in other areas, they take spelling errors as a negative rather than a positive sign. An e-mail message that we received from a
person who was writing a <manuel» to be used in teaching children to read and spell caused us to question this person's competence. We reacted this way even though «manuel» is a plausible rendition of the sounds in the word manual. We tend to forgive typographical errors more easily than spelling errors. For example, the e-mail message just cited had «awarnss» rather than «awareness» in one sentence, but the word was correct elsewhere. This led us to conclude that this particular mistake reflected a slip rather than a lack of knowledge. We may be a bit extreme, but we aren't the only ones to draw negative conclusions about writing that contains many spelling errors. One group of researchers (Kreiner, Schnakenberg, Green, Costello, \& McClin, 2002) studied US university students' impressions of writers who produced texts with and without spelling errors. The two types of texts were the same in all other ways. When spelling errors were infrequent, affecting less than $2 \%$ of the words, the students' perceptions of the writer were unaffected. When the error rate was higher, the students tended to rate the writer as poor or even unintelligent. The researchers reported that errors such as «cetnered» for «centered», which could be interpreted as typographical, tended to lead to less negative perceptions of the writer than errors such as «sentered», which appear to reflect a lack of knowledge about the orthography. People know that others may make judgments about them based on their spelling and act accordingly. One woman we know delayed writing thank-you notes for the gifts that she had received at her wedding on the belief that people would judge her negatively because of her poor spelling.

Teachers of subjects such as history or economics often attempt to assess students' writing on the basis of their understanding of the concepts. However, even when asked to grade essays on the basis of content only, teachers often can't prevent themselves from considering other factors. They tend to assign lower grades to essays that contain spelling errors than to otherwise similar essays that do not (Marshall, 1967; Marshall \& Powers, 1969; Scannell \& Marshall, 1966; but see Chase, 1968). One study found no significant effect of spelling errors when the rate was less than $2 \%$ but an increasing tendency to give low scores as the rate of errors increased beyond that (Marshall, 1967). Grading of handwritten papers is also influenced by the quality of the handwriting (Briggs, 1980; Chase, 1968; Markham, 1976). Teachers tend to downgrade papers with poor spelling and handwriting, in part, because these papers take extra time and effort to read. A teacher who knows that she is having difficulty understanding a student's essay may not know exactly why, and she may attribute her difficulties to poor argumentation or poor organization on the part of the student. Another reason why essays with poor spelling and poor handwriting tend to be downgraded is that orthographic knowledge relates, albeit weakly, to intelligence, general knowledge, and composition skills (Kreiner et al., 2002; Lewellen, Goldinger, Pisoni, \& Greene, 1993; Olinghouse, 2008). Students who make many errors in spelling, capitalization, and punctuation tend to show poor organization and content as well (Olinghouse, 2008).

Children are ardent enforcers of cultural norms, including those related to spelling and handwriting. The child who said that, if you are a poor speller, "everybody's going to think that you don't go to school... and your mother doesn't care" (Wilde, 1992, p. 163) clearly thought that orthography is important. So did the child who said that, if you are "police ladies or men you have to write nice so they can understand" (p. 163). Support for the idea that children think that spelling is important comes from a study in which Canadian 7 - to 11-year-olds read stories written by other children. Some children read versions of the stories in which $8 \%$ of the words were misspelled in plausible ways; other children read versions in which all of the spellings were correct (Varnhagen, 2000). The children judged the stories with spelling errors to be less well written, less interesting, and harder to read than the stories without. Moreover, children judged the writers of the stories containing spelling errors to be worse students and less careful than the writers of the stories without spelling errors. But the negative judgments don't generalize to all aspects of life. The children didn't say that they wouldn't want to be friends with the poor spellers. We feel the same, and one of us is even married to someone who isn't a good speller.

To summarize, learning to use the writing system of one's language is more than a painful necessity. It helps writers to focus on the message, and it helps readers to understand it.

### 1.3 How Can Orthographic Knowledge Be Achieved?

Children need to achieve a level of fluency with spelling, letter formation, and punctuation in order to write well. What is the best way for them to do this? In this section, we contrast two different approaches: the whole-language approach and the phonics approach. We return to the topic of teaching throughout the book, and the information presented here is designed to provide a foundation for those later discussions.

### 1.3.1 Discovery Learning and the Whole-Language Approach

One set of ideas about the learning of orthography stems from the self-directed discovery view of learning, which says that children discover the principles behind a system as they interact with it and try to use it. Formal lessons about the workings of the system are thought to be unnecessary, even harmful. Learners will entertain incorrect hypotheses and make mistakes, but it is believed that they will improve their hypotheses after comparing their responses to those of others or noting inconsistencies in their own performance. Theories of this kind have been labeled constructivist, for they emphasize the constructions or hypotheses that emerge from children's minds as they try to understand the world $\left(\$ 4.3\right.$; the $\int$ symbol points to other sections of this book that provide further discussion on a topic). Constructivists believe that children follow their own internal timetable and that attempts to hurry them or to make them all
learn in the same way do more harm than good. Before considering how these views have been applied to orthography, we discuss some more general theories that emphasize discovery learning.

Psychologists in the Gestalt tradition stressed the role of the learner in their discussions of insight learning. In one set of studies, chimpanzees were confronted with problems such as how to obtain a banana that was hanging high out of reach in the cage (Köhler, 1925). The problem could be solved only by using techniques that were new to the chimpanzee, such as climbing on a stack of boxes to reach the banana. The chimpanzees sometimes solved such problems suddenly, after a period of time during which they were not actively trying to reach the banana. Restructuring of knowledge appeared to be taking place during this time, with the chimpanzee moving from treating boxes as playthings to be tossed around, as they had been in the past, to supports that could be climbed on to reach the banana. This restructuring seemed to happen more quickly if the box and the bananas were arranged so that chimpanzee could see them both at the same time; that is, if the environment was structured to aid learning.

Piaget's stage theory of cognitive development also stressed discovery and insight (Piaget, 1970). Piaget viewed learning as hypothesis testing and children as little scientists. According to Piaget, children take in information from the world around them and interpret it in light of their current knowledge. The input is said to be assimilated into the schemas or cognitive frameworks that the child possesses at the time. Piaget believed that early schemas are universal, in that children in different societies construct the same schemas. He also believed that the schemas were rather stable: A child doesn't give up on a schema in response to one or two disconfirming inputs, just as a scientist doesn't give up on a theory in response to one or two experiments that don't work as expected. Piaget held that children are reluctant to modify their schemas until they have gathered substantial counterevidence. This means that their early schemas may deviate rather markedly from the patterns in the world around them. When children are confronted with many new inputs that can't be assimilated, however, Piaget said that they accommodate, or change their schemas. Piaget described development as consisting of fairly long periods of equilibrium, or stages, during which children's schemas are rather stable and the children show a good deal of consistency in their thinking. These stages were held to be separated by short periods of rapid accommodation until a new equilibrium -a new cognitive stage-is reached. "Each time one prematurely teaches a child something he could have discovered for himself," Piaget (1970, p. 715) stated, "that child is kept from inventing it and consequently from understanding it completely."

The discovery approach has been influential in education. For example, Papert (1980) applied it to the learning of computer programming. He suggested that children learn the Logo computer programming language by immersing themselves in a Logo environment. As children try to program,
they generate hypotheses about how the language works. Children test their hypotheses by writing programs and observing the results. If a program doesn't work, children are expected to change their hypotheses. In a pure self-directed discovery curriculum, teachers provide an environment in which these things can happen, but they don't provide organized lessons or corrective feedback. In less radical versions of discovery education, teachers are more actively engaged in providing feedback and answering children's questions.

As applied to the domain of written language, the discovery approach is often called whole language (Goodman, 2005). Advocates of this approach believe that children will learn what they need to know about handwriting, spelling, and punctuation by observing the writing on signs and commercial print, by being read to from storybooks, and by trying to write and read by themselves. Lessons in which children practice isolated letters or words or are taught generalizations about spelling are considered ineffective and unnecessary. Indeed, advocates of the whole-language approach believe that such lessons impede children's understanding that the goal of writing is to communicate meaning. Whole-language advocates believe that children should learn to write by doing it, inventing spellings for words using the hypotheses that they hold. They believe that, over time and with exposure to meaningful print, children will replace incorrect hypotheses with correct ones. This is the process that children follow in learning to speak and understand, according to whole-language advocates, and it is the process that they should follow in learning to read and write. The whole-language approach has been popular at various times, including in the United States and New Zealand in the later 1900 s.

Some teachers who advocate a whole-language approach don't tell children when their invented spellings differ from conventional spellings, believing that this would hinder creativity and written expression. Indeed, some teachers don't tell children the conventional spellings of words even if the children ask. As long as children have ample opportunity to read and write, these teachers believe, their spelling and handwriting will improve naturally and with little effort on the children's part. Perhaps not coincidentally, this approach also requires less effort on the part of the teachers. Other teachers who follow a whole-language approach provide information about spelling, punctuation, and letter formation when "a particular child needs it for something else the child is working on" (Edelsky, 1990, p. 9). For example, a teacher may help a child spell king or remind him how to form the letter «k» when the child is writing a story about kings and has a question about this word.

### 1.3.2 Direct Instruction and the Phonics Approach

Opposing the pure discovery view is the idea that children benefit from direct instruction. Whereas Piaget compared children to scientists, others point out that a perfect scientist, using experiments alone, couldn't rediscover all human knowledge within a single lifetime (Shafto, Goodman, \& Frank, 2012). Children must
not discover everything they learn. In learning to write and spell, as in other areas, children must be helped by more knowledgeable members of their society.

Whereas whole-language teachers may provide instruction about orthography to individual students on an ad hoc basis, direct instruction is most commonly associated with lessons that are planned in advance and delivered to groups of students. Lessons may include explanations, discussions, and student practice, and they may deal with isolated letters and lists of unconnected words. The teacher provides corrective feedback when students err. Although most advocates of direct instruction accept that children learn a good deal informally, they maintain that pure, unguided discovery isn't an efficient way in which to master orthography and certain other complex skills.

A number of different methods of direct instruction have been proposed for spelling. A traditional view is that children should learn the spelling of one word at a time through a process of rote visual memorization. In a number of US classrooms, children receive a list of spelling words on Monday, study them during the week, and are tested on Friday. The words in a list may be chosen on the basis of frequency of use or relevance to a theme, such as the weather, rather than on the basis of shared phonological or orthographic features. Pupils may be directed to copy each word several times, on the view that this is a good way to commit words to memory, or they may be directed to memorize the spellings by visualizing them in their minds. Similarly, Chinese children may learn characters by writing them repeatedly, and they may not be taught about the components that make up the characters. Students who are taught by such methods aren't expected to write words or characters that they haven't studied. Thus, they don't write much on their own until they have memorized a good many items.

Another approach to direct instruction for alphabetic writing systems, which represent speech at the level of individual sounds or phonemes, is to explicitly teach children about the connections between phonemes and letters. In phonics instruction, children are taught a letter or letter group that corresponds to each phoneme. For example, English-speaking children are taught about the link between «w> and /w/ and the link between <sh> and / $/ /$. These rules are taught to classrooms of students or to smaller groups following a predetermined sequence. The rules are explained using generic statements such as "/b/ is spelled with «b»," statements that are meant to reflect core properties of a category, in this case, /b/. In most phonics programs, more time is spent on reading rules-those for deriving the sounds of printed words from their spellings, or decoding-than on spelling rules. For example, there is more stress on translating 〈b> to /b/than on translating /b/ to <b>. Children will be able to extend their knowledge of letter-to-sound rules, it is thought, to the sound-to-letter direction. Advocates of phonics instruction maintain that children who learn rules that link letters and phonemes will be able to pronounce and spell new words on their own, as long as they are regular words that follow the taught rules. Words that deviate from the taught rules, such as sword, are introduced as exceptions to be individually memorized. Teachers sometimes refer to these
words as sight words, because children are urged to read them quickly, without trying to translate the individual letters into sounds.

Before instruction about correspondences between sounds and spellings begins, or when it first starts, children may be taught to break up spoken words into smaller units of sound. Instruction in phonological analysis (sometimes also called phonological awareness) may cover the level of syllables, as when children learn to divide the spoken word friendly /fıendli/ into two parts (3). It may cover the level of onsets and rimes, the rime (a spelling variant of rhyme) being the nucleus plus any following consonants ( 3 ; see Introduction, "Symbols and Abbreviations," 3, for additional phonetic definitions). Thus, children may be taught how friend shares its onset with frog and its rime with send. Phonological analysis instruction may also target the level of phonemes, teasing apart the different sounds in an onset or rime. The term phonemic analysis is used to refer to this level of analysis. For example, phonemic analysis skills may be taught by pointing out that the spoken word friend begins the same way as flip. Phonological analysis instruction is based on the idea that learning to read and write an alphabet requires children to think about language in terms of smaller units-something that is different from and more challenging than using language to speak and comprehend. Indeed, studies show that phonological analysis instruction benefits children learning alphabetic scripts (Ehri, Nunes, Willows, et al., 2001).


Given that basic phonics instruction focuses on a small set of rules and that it is taught primarily in the reading direction, it is normally limited to the first few years of primary school. After this point, children may receive additional direct instruction that is focused on spelling. For example, some spelling programs for English explicitly teach children to double the final consonant of a stem such as «hit> when the suffix «ing> is added. This rule differs from the ones previously discussed in that it involves morphemes, or the smallest meaningful parts of words $(\mathbb{}(\sqrt[2]{2} \cdot 2.2 .1)$. Children may practice this and other rules by studying lists of words that exemplify the rules or by participating in other activities.

We have discussed whole language and phonics as distinct approaches, but elements of the two may be blended in practice. For example, a teacher may explicitly show pupils how to spell and decode words but may also encourage children to produce their own writing, at times with minimal guidance and feedback about spelling.

### 1.4 Spelling and Reading

Spelling, our focus of interest in this book, is harder than reading. When children or adults are asked to read words aloud on one occasion and to spell the same words on another occasion, they usually do better in reading. That is, there are some words that they read aloud correctly but can't spell correctly. An example is the adult who had seen the correct spellings of parents and whiskey many times but who usually spelled the words as «perants» and «wiskey» (Hatfield \& Patterson, 1983). Spelling is harder than reading not only in English, where many sounds have more than one possible spelling, but also in Italian, where there is only one way to spell most sounds (Bradley \& Bryant, 1979; Cossu, Gugliotta, \& Marshall, 1995).

There are many reasons why spelling is harder than reading. One is that readers can usually assume that a written form they see stands for a spoken word they know. This can allow them to understand the written word even when their memory for its spelling is incomplete. For example, a girl may be able to guess what <alligator> means after she has decoded the first three syllables. She will be even more likely to guess correctly if an alligator is pictured on the page. Seeking to understand what she reads, the child may persist in decoding the word <alligator> until she generates a spoken word she knows that makes sense. This allows her to provide her own corrective feedback-in effect, to teach herself how to read this word. Although lack of knowledge of whether alligator ends with «or», «re», or «er» may not hurt the child's reading, it will probably hurt her spelling. Because the child doesn't have a full list of the written words of her language, she can't rule out «alligatre» and «alligater» as potential spellings. She can't provide her own corrective feedback for spelling, but must consult a teacher, a spell-checker, or a dictionary.

Learning to spell a word takes effort, and children's motivation to make that effort may be lessened by the knowledge that, if they misspell a word, the problem will be the reader's more than theirs. Children know that, if a misspelling is fairly close to the correct spelling, readers probably won't have serious problems. For this reason, children may devote less effort to spelling than to reading.

Another reason why spelling is harder than reading is that the difficulty of spelling tends to increase more rapidly over time than the difficulty of reading. As we will discuss in chapter 2 , this reflects the fact that the pronunciations of words change from one generation to the next. Written language, on the other hand, is more conservative. When pronunciations change, spellings are often not updated to reflect the changes. The typical result is that the links from sounds to spellings are more complex than the links from spellings to sounds.

Yet another reason that reading is easier than spelling is that reading practice usually comes for free when people spell. People see what they have written and can read it back. Indeed, a person who knows how to read can hardly prevent herself from reading something that is put in front of her. Reading a
word, in contrast, doesn't usually involve spelling it. The asymmetry of practice between spelling and reading makes spelling harder. Support for the idea that practice in reading doesn't fully carry over to spelling comes from a study in which US teachers set aside an extra half hour each day for recreational reading, starting from when students were around 6 years old (Pfau, 1967). At the end of 2 years, the children who had done extra reading liked to read more than the children in a control group. They also appeared to have a larger reading vocabulary. However, the pupils who had done extra reading didn't spell better than the children in the control group.

Laboratory studies confirm that children and adults tend to show relatively poor memory for new spellings they have encountered when reading for comprehension. Consider a study (de Jong \& Share, 2007) in which Dutch 8 -year-olds silently read stories that contained six instances of a made-up word. Some of the children saw the made-up word spelled one way, such as «weip», and the rest saw it spelled another way, such as «wijp». Both of the spellings would be pronounced the same way by Dutch spelling rules. The children weren't told to pay special attention to the novel spellings, and they didn't know that their memory would be tested. When the children were given a surprise test several days later, they produced the spelling that had appeared in the story $55 \%$ of the time. When given two spellings, «weip» and «wijp» in this example, and asked which had appeared in the story, $69 \%$ of the children's answers were correct. The children had retained some information about the words' spellings, but a modest amount. Similar results have been reported in studies with other age groups and other languages (Bowey \& Muller, 2005; Ormrod, 1986a; Share, 1999). The effects of free voluntary reading on spelling are modest because readers normally focus on meaning rather than form. They may not form a lasting memory for a new word's spelling after having read the word a few times in a story. These findings speak against the whole-language view that the "easy way [to promote spelling] is to encourage a lot of reading, especially free voluntary reading" (Krashen, 1989, p. 454). Reading a lot has many benefits, but it doesn't necessarily make people good spellers.

### 1.5 Orthographic Reform

So far, we have assumed that children should learn about writing systems as they currently exist. Another idea is that writing systems should be changed to make it easier for children to learn to spell correctly. One of us was once taken to lunch by a man who believed that many problems in the United States stem from the illogical nature of English spelling. He founded an organization that advocated the use of simplified spelling, and he changed the spelling of his name from 〈Abe> to 〈Ayb>. We pointed out that, although changing the English writing system could have some benefits, these benefits might not be as great as he assumed. We explained, for example, that even some very predictable aspects of English spelling, such as the consonant clusters of words
like swim and flat, cause difficulty for children. Other letters, such as the «a> of health, don't make good sense in terms of pronunciation but show how a word relates to others, in this case heal. Ayb listened politely but was unconvinced that certain aspects of spelling, both in English and other languages, are better motivated than they first appear.

Massive changes to the shapes of letters or the spellings of words, even when desirable in theory, would be difficult in practice. After explaining that the initial $\langle\mathrm{ph}$ 〉 of phone had been changed to $\mathrm{f}>$ in the Netherlands to make the word easier to spell, some researchers asked Canadian 6- to 12 -year-olds whether a similar change should be made in their country. Only a minority of children said that it should. The other children argued that people would be confused if the spelling changed or that they themselves already knew the spelling and didn't want to learn a new one (Downing, DeStefano, Rich, \& Bell, 1984). Orthography is conservative, and people are, too. We don't expect to see large-scale spelling reforms of English soon in Canada or other countries. In this book, we focus on writing systems as they currently exist.

### 1.6 Past Work on Writing Systems and How They Are Learned

For centuries, scholars and grammarians focused on written texts, giving primacy to writing over speech. They regarded writing, largely because of its permanence and physicality, as language proper. Speech, because of its ephemeral nature, was seen as less important. As interest in phonetics and dialects increased in the 1800 s, the study of writing began to be separated from the study of spoken language. Linguistics came to be defined as the study of spoken language, and writing was seen as mere transcription of spoken language. The influential linguist Saussure (1916/1986), for example, claimed that spoken forms were the proper object of linguistic study. Likewise, Householder (1969, p. 886) stated that "language is basically speech, and writing is of no theoretical interest." Such views discouraged mainstream linguists from studying writing for some time.

In the latter part of the 1900s, some linguists became more interested in writing. They began to see it not just as a transcription of spoken language but as a system with rules and patterns that should be studied in its own right. Chomsky and Halle (1968, p. 49) contributed to this change when they claimed that the English writing system "comes remarkably close to being an optimal orthographic system" for the language. However, the study of writing is still a minor part of linguistics. Linguistic work on writing continues to focus on the history and description of specific writing systems and the classification of writing systems. Less attention has been paid to general principles that underlie all writing.

Psychologists, unlike linguists, have had a long and continuing interest in writing and reading. Huey (1908/1968, p. 6), reviewing the research on reading that had been done in the late 1800 and early 1900s, stated that "to
completely analyze what we do when we read would almost be the acme of a psychologist's achievements, for it would be to describe very many of the most intricate workings of the human mind." Huey, like later psychologists, was drawn to the study of reading and writing because these tasks require perception, attention, memory, and expertise: all mental processes that psychologists want to understand. Psychologists sometimes study these processes using artificial laboratory tasks. But real-life tasks such as spelling and reading provide a better opportunity to study expertise and its development, given the many years of experience that people have with these tasks outside the laboratory. The study of spelling and reading has direct practical implications as well. For these reasons, psychologists who specialize in the fields of cognition, development, and language have often studied reading. They have done research on spelling too, but much less research on spelling than on reading. One goal of this book is to help even the score.

Educators, of course, have long been interested in how children learn to read and write and how they should be taught to do so. Some educational research focuses on the pros and cons of specific teaching methods. Other research examines why some children learn to read and write more easily than others and how special groups of people, such as those who are deaf or have brain injuries, cope with these tasks. Many psychologists who study spelling and reading have also studied differences among learners.

Behavioral research on the learning and use of writing systems, whether by psychologists or educators, has concentrated on a few writing systems-primarily alphabetic systems and, within those, primarily English. This is unfortunate, because research that is limited to one writing system or one set of systems might lead to incorrect conclusions (Share, 2008). As one potential example, studies of English have led to the idea that knowing the locations of word boundaries in speech, sometimes called having a concept of word, is a precondition for learning to spell and read (Tunmer, Bowey, \& Grieve, 1984). That is, it is important for children to know that the spoken sentence "Brett has two cats" contains four words so they can understand why the corresponding written sentence is written with four groups of letters that are set off by spaces. However, as we discuss in chapter 12 , the intuitive understanding of words that is shared by literate speakers of languages such as English comes, in part, from their knowledge of writing. Some writing systems, such as that of Vietnamese, don't have breaks between words, and it would be difficult to argue that knowledge about word division is critical for literacy in such systems. What may seem universal if one confines one's attention to a few alphabetic writing systems may not be universal if one looks more broadly.

### 1.7 Our Approach

In this book, we review the research on how children learn the writing system of their language. We focus on children's ability to use the writing system for
writing rather than reading, in part to counteract the stronger emphasis on reading in many of the available studies. We seek to integrate the research on spelling across ages, writing systems, and different aspects of orthography using a single theoretical framework that we call IMP, an acronym for the Integration of Multiple Patterns. We describe this theory in more detail in chapter 4.

We and other investigators have published studies in specialist research journals that are filled with numbers and statistics. In this book, we avoid such details. We reference the original studies for readers who are interested in details about methods and results that aren't provided here. When there are many studies on a particular topic, we cite just a few so as not to overload readers. When research on a particular topic is lacking, or when evidence is mixed, we indicate that the findings are unclear but may give our best guess. We try to make clear when we are speculating and when we are reporting well-documented findings. We include anecdotes in some places in order to illustrate findings that have been supported by research studies. Anecdotes and examples, when citations aren't given, are our own observations.

When we discuss research findings with children, we generally provide the children's ages rather than their grades in school. This is because the labels for different educational levels vary from one country to another and because direct translation can be problematic. But reporting results by age has some potential problems. When considering a study of Finnish 7 -year-olds, for example, it can be important to know that this is the first year of formal literacy instruction in that country, as in other Scandinavian countries. In many other European countries, formal literacy instruction begins around the age of 6, and this is often true in the United States as well. In England and Scotland, literacy instruction begins at 4 or 5 . We remind readers of these differences when it seems important to do so.

To understand how children learn to use writing systems, it is important to understand the nature of writing systems themselves and the nature of human learning. We have organized the remainder of the book with these things in mind. Chapter 2 discusses the nature of writing systems. Because writing systems reflect language, this chapter also reviews some aspects of language structure that are relevant for the learning of writing. A broad understanding of writing systems is helpful for understanding children's learning of writing, and so we consider many different systems and types of systems in chapter 2. In chapter 3, we turn to the topics of learning and teaching. We discuss basic principles of human learning that apply across a variety of domains. Given that learning a spoken language provides an important foundation stone for learning a written language, we also consider some of the special characteristics of language learning. Chapter 3 sets the stage for our discussions, in later chapters of the book, of how children learn to produce writing. In chapter 4, we review prominent theories of spelling and spelling development and we introduce IMP. Together, chapters 2,3 , and 4 provide a foundation for the remainder of the book.

The central portion of the book consists of chapters 5 through 12. In each of these chapters, we review the research on how children learn about a specific
aspect of orthography. In some of these chapters, we also provide information about how writing systems deal with that aspect of orthography, information that is more detailed than that given in chapter 2 and that is best appreciated by readers when presented in the same chapter as the material on children's learning. In each of chapters 5 through 12 , we consider the findings reviewed in light of IMP and other theories of how children learn to spell. Implications for teaching about each aspect of orthography are also covered in each of these chapters. Detailed discussions about which specific patterns of particular writing systems should be taught at which ages are beyond the scope of this book. Orthography, in the broad sense in which we use the term, includes more than the spelling of individual words. Thus, the chapters in the central section of the book cover not only how children learn to spell words but also such things as how they learn to punctuate and capitalize.

Part of the organization of the central section of the book is chronological. For example, a chapter on children's early knowledge about the visual characteristics of writing (chapter 5) precedes a chapter about how older children spell complex words (chapter 11). Other aspects of the book's organization are topical. For example, chapter 8 examines how children learn about and produce the shapes of writing's basic units, and it reviews evidence from a variety of age groups. We adopt this organization in an attempt to bridge the gap between studies of beginners and studies of more advanced learners that has characterized some past research.

What is often considered the beginning of learning to spell-inventing spellings such as <jup> for jump-is not discussed in earnest until chapter 10. This may strike readers as quite late. However, one theme of the book is that people are not born knowing even the most basic aspects of spelling. They have to learn such things as how writing differs from drawing and that it stands for language. Thus, there are many things for children to learn and much material for us to cover before spellings such as <jup» for jump are even possible.

In each chapter in the central section of the book, we discuss studies of children who are learning a variety of languages and scripts. Unlike the authors of some other books, we don't devote separate chapters to the learning of specific languages or types of writing systems. The organization that we use is helpful in considering similarities and differences across learners of different writing systems and in articulating the principles that underlie orthographic learning. Given the nature of the published research, much of the evidence that we review comes from children who are learning to spell in English. We have made special efforts to find studies with learners of other languages, but such studies don't always exist. This means that we are unable to provide evidence about learning to spell for some of the writing systems that we discuss in chapter 2. Some of our readers, we hope, will take up the challenge of providing that evidence. Theories of spelling and its development will be on stronger ground if they are based on evidence from a variety of languages and writing systems.

The final chapter of the book summarizes the findings and their implications. We evaluate the theories of learning to spell in light of the evidence
reviewed and pull together the implications of the research for instruction. In addition, we consider how learning to spell influences children's reading and how it influences other aspects of their language and cognition.

We anticipate that some readers will be more interested in some aspects of the book than others and may wish to concentrate on specific chapters. To allow for this, there is some redundancy across chapters. A term is defined the first time it is used in the book. A reader who encounters an unfamiliar term may look it up in the index and find its definition.

Our interest in this book is in the learning of orthography by children who are neurologically and perceptually unimpaired. When we cite a study that includes, for example, participants with brain injuries as well as those without, we refer to the results of the typical group. A complete analysis of how children learn to spell would include an understanding of how knowledge about orthography is encoded in the brain and how it is translated into physical movements. However, these topics are beyond the scope of this book. When we cite a study that includes measures of brain functioning, for example, we refer to the behavioral findings of the study and not the measures of brain function.

We are interested in the learning of orthography by children in modern literate societies, and so almost all of the data that we review comes from mainstream children in these societies. There are differences among such children in the amount of exposure they have to print and in their learning of it, but we don't review studies of these topics. One reason for this is that writing is ubiquitous in modern societies: It would be almost impossible to shield a child from seeing it or hearing about it. Another reason is that differences among children in spelling skill are often quantitative rather than qualitative (Bourassa \& Treiman, 2008; Cassar, Treiman, Moats, Pollo, \& Kessler, 2005; Protopapas, Fakou, Drakopoulou, Skaloumbakas, \& Mouzaki, 2013). Within a language and culture, children who are slow at learning to read and write tend to have difficulty with the same orthographic features as children who are fast. For example, an 8 -year-old who is slow in learning to spell in English may have difficulties with consonant clusters. A fast learner may have mastered the spelling of clusters at the age of 6 . However, the slow 8 -year-old's errors are likely to be similar to the fast learner's errors at the age of 6 . We focus in this book on the hurdles that both slow and fast learners face.

There has been a division in the past between those who study how writing systems work, generally linguists, and those who study how children learn to use writing systems, often psychologists and educational researchers. That division is unfortunate, because one needs to understand the nature of a toolwhether it be calculus or written language-in order to understand how children learn to use the tool. Moreover, the study of how writing systems work and how they have changed over time can provide valuable cues about what aspects of these systems are easier and harder for their users. In the chapter that follows, we consider the nature of writing systems as a basis for understanding how children learn to use these systems.

## CHAPTER 2 <br> Writing Systems

IN THIS CHAPTER, WE discuss the types of writing systems that people have developed and the general principles behind how they work. Because most writing is based on spoken language, the chapter covers certain aspects of spoken language, too. We seek to provide a broad overview of the nature of writing systems as a foundation for the discussions, in later chapters, of how children learn to use these systems. By studying how writing systems work and the sorts of complexities they include, we gain insight into what children must learn and what difficulties they face. More detailed information about particular aspects of writing is presented in some of the later chapters when we discuss how those specific aspects are learned.

We present information about a number of different writing systems in this chapter. We don't discuss all of these systems in the later chapters on child acquisition studies, in part because there isn't always much research available. Our goal in this chapter is not to teach the writing systems themselves but to show the wide range of variation among them, as well as the underlying similarities. An understanding of these similarities and differences is important for understanding how children learn to produce writing. A number of the properties of writing systems reflect the fact that people invented writing and people must learn to use it. Studying what writing systems have in common, therefore, provides some hints about how the systems may be learned. Even those who are interested only in the acquisition of one particular writing system will gain a better understanding of how that system works when they compare it with the systems adopted by other societies. They may discover that the basic principles of very different writing systems have echoes in aspects of their own writing system that would otherwise seem like inexplicable quirks, and they may discover that some aspects of their writing system that they have assumed to be universal are not in fact shared by other systems.

We use the term writing system fairly narrowly in this book, to refer to a specific system of written communication. As a rule of thumb, we say that
each language has its own writing system, because each language has its own set of conventions for how written signs map onto units of the language. We use the term scripts to refer to sets of signs that writing systems draw from. For example, English and French use two different writing systems that both draw from the same script, the Latin alphabet, whereas Hebrew and Yiddish use two different writing systems based on the Hebrew script.

We begin this chapter by considering the outer form of writing, its visual characteristics. We then proceed to a discussion of writing's inner form, which has to do with what it represents. We make this distinction, in part, because the two aspects of writing are rather different. As we will see in later chapters, children can and do learn about some aspects of writing's outer form before they learn about its inner function. In later sections of the chapter, we consider how writing represents language, including what aspects of language it represents and what it leaves out. We examine how spoken languages change over time and how this can lead to complexities that cause problems for spellers.

### 2.1 Outer Form of Scripts

One approach to writing systems is to consider their outer form, their visual characteristics. One of the most obvious visual characteristics of modern writing systems is that they are formed with lines. We don't mean only straight lines but also curved ones: any tracing of a point through two-dimensional space. To use a term traditional among historians of writing (A. J. Evans, 1894), the symbols are linear. They require no shading, no fill, no color other than that needed to distinguish the writing from the background, and no distinctions between lighter and darker lines or wider and narrower lines. Although the symbols of most modern writing systems are linear, there are some boundary cases. Traditional Latin fonts have thin and thick lines, and many of them end in elaborations called serifs. However, these artistic flourishes are rarely needed to distinguish one letter from another, and they are omitted when people write with an instrument like a pencil or ballpoint pen.

Although linearity is a universal characteristic of modern writing, different writing systems differ in many aspects of their appearance. Some of these differences may be seen in the versions of Article 1 of the Universal Declaration of Human Rights (United Nations, 1948) that are shown in (1) through (3). For example, Chinese characters fit into a virtual square and are arranged in a virtual grid (1). Most are moderately complex. There are many lines, squares, and sharp angles, but no circles or semicircles. Korean hangeul letters don't look much like Chinese characters, but usually two or three letters at a time are packed into virtual squares representing syllables, giving this alphabet a feel reminiscent of Chinese (2). Nevertheless, hangeul and Chinese are discriminable by such features as the frequent circles found in the former, as well as spaces between words. The Kannaḍa script of southern India (3) is notable
for its preponderance of rounded shapes and its distinctively hooked tops，and so forth．
（1）Chinese
人人生而自由，在尊严和权利上一律平等。他们赋有理性和良心，并应以兄弟关系的精神相对待。
（2）Korean hangeul
모든 인간은 태어날 때부터 자유로우며 그 존엄과 권리에 있어 동 등하다．인간은 천부적으로 이성과 양심을 부여받았으며 서로 형 제애의 정신으로 행동하여야 한다．
（3）Kannaḍa

 సైేంలదరరె భాదేదిందే దెతిఁసెబొలరు．
（4）English in Latin script
All human beings are born free and equal in dignity and rights．They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood．

The unity of design within a script could help children to identify it，even if they don＇t yet know many of the individual characters in the script，much less the function of the characters．The similarity among characters may also help children to understand that the symbols go together to form a system．

## 2．2 What Writing Systems Represent

We turn now to the inner form of writing，considering what the signs of a writing system represent．We briefly look at writing systems that directly rep－ resent ideas，and then we discuss writing systems that represent elements of language．

## 2．2．1 Representing Ideas：Semasiography

One tack for solving the problem of the evanescence of language is to use a means of communication that has nothing to do with language．For at least 40,000 years，artists have been making sculptures and paintings that manage to communicate across cultures and across the millennia．Might writing repre－ sent ideas in much the same way that art does？

On the one hand，art often conveys information in detail and emotions with immediacy，trumping speech in its ability to do so．On the other hand， conveying information through improvised art requires skill and patience， and even then may not succeed in conveying types of information that lan－ guage could convey with ease．Consequently，conventions arise for visually
representing important recurring ideas with precision or speed, or both. It is useful to consider the nature of those conventions, for such consideration can shed light on the similarities and differences between semasiography and writing.

Religious and mythological art often involves an elaborate system that allows people and events to be identified by characteristic images. For example, the sea god Neptune was routinely depicted in European art as carrying a trident, a three-pronged fishing spear, so that viewers would have no trouble identifying him. Later, the trident was simplified and often used outside of artistic contexts as a symbol for Neptune (5). Astrologers use it and a set of similar symbols to represent the planets that were named after the gods in question. Unlike a figure of the god Neptune in a painting, the sign $\Psi$ can be drawn in seconds.

## (5) $\Psi$ 'Neptune’

Systems of representation like those of the astrological planet signs have been called semasiographies (Haas, 1976). The name (from Greek words meaning 'meaning' and 'writing') is meant to suggest that the signs directly represent a meaning, not a word. The symbol $\Psi$ can be read as Neptune or as the eighth planet or, especially by Greeks, as Poseidónas. The various signs in a semasiography are called semasiograms. More generally, the basic signs of any writing system are called characters. Thus the characters of a semasiography are semasiograms and, as we will discuss later, the characters of an alphabet are letters and punctuation marks.

In certain domains, a semasiography has some advantages over ordinary writing. The brevity of semasiograms may make them quick to write and to recognize. They also take up less space than words. Moreover, the fact that semasiograms are independent of language means that, in principle, a speaker of one language has no inherent advantage over a speaker of any other language. All humans put in the same amount of effort to learn the symbols.

The succinctness and language independence of semasiograms have made them very popular and useful in the modern world. One important semasiography is mathematical notation. On first consideration, a speaker of English might think that a digit like <2> is a shorthand way of representing the word two. On second consideration, though, it is clear that the digit represents a mathematical concept, not a word. Consider, for example, how it is pronounced in notations such as <21>, <12», <1/2>, and <x2>. Mathematical notation follows principles that are largely independent of language. Modern mathematical notation is used throughout the world with only minor graphic variations that have little or nothing to do with the language used by its readers and writers. Another semasiography that has become important in recent times includes the symbols used on electronic equipment (6) and computer displays (7):
(7) $\Delta$ 'mail'

Semasiographies can be quite sophisticated and, in the specific domains they are designed for, convey a lot of information succinctly. But no semasiography in general use is capable of expressing the full range of thoughts that one can express in speech. None can clearly express the ideas in the Universal Declaration of Human Rights (1-4; United Nations, 1948), for example. This hasn't stopped some people from trying to invent such a semasiography. For example, Bliss (1978) and Blissymbolics Communication International (Wood, Storr, \& Reich, 1992) developed a semasiographic communication system consisting of about 900 semasiograms and rules for combining them. Originally conceived as a way of fostering international communication, it is now used mostly as a means of communication for linguistically disabled individuals. Blissymbolics are meant to be read and written, but they don't map into any particular language. For example, (8, File:Bliss cinema.png, 2005) could be translated several different ways into English or any other language:


### 2.2.2 Representing Speech: Glottographic Writing

The semasiographies that we have discussed so far are limited in what they can express. How can a system of permanent communication express any and all thoughts? The only way that cultures have ever found to do this is to piggyback off language. Writing that is based on natural human language is called glottography, from the Greek word for "tongue" or "speech". Instead of representing meaning directly, the characters of glottographic writing-glottograms-represent the components of language, which itself represents concepts. Writing systems have many differences in their outer form, but all full-scale systems in regular use are glottographic. This is a feature of writing that children must learn.

To understand how glottographic writing works, we first need to discuss how language works. A language can generate an infinite number of different sentences, so writing couldn't work by having a separate written sign for every possible sentence. Fortunately, sentences are composed of parts. If sentences are broken down far enough, the number of different parts becomes small enough to be enumerable and learnable. Perhaps the most obvious candidate for a manageable constituent (component) of a sentence is a word. A language has a large but finite number of words. If one could invent a separate character for each word, one would have a writing system.

This is the tack taken by some writing systems, called logographies ( $\mathbb{2 . 2 . 2 . 1}$ ). The other tack is to conceive of speech as a sequence of sounds, without regard to meaning. If speech is broken down finely enough, there are a limited number of different, contrasting sounds. If one assigns a different character to each of the different sounds of a language, one has a phonogra$p h y$ (§2.2.2.2).

Each of these two types of glottographic writing systems, the logographic and the phonographic, will be discussed in detail in the following sections. But to make sure that the general concepts are understood, consider now the English words see, sea, and ocean. Further, let us stipulate that sea and ocean mean the same thing. In a pure semasiography, such as Blissymbolics (Blissymbolics Dictionary, 2012), sea and ocean are written the same way (9), because a semasiography is only concerned with meaning, not sound. But see is written in a completely different way from sea (10):
(9) $X X \sim$ 'sea, ocean'
(10) $\hat{\bigodot}$ 'see'

In a pure logography, there would be different characters for all three of these words, by definition. In a pure phonography, sea and see would be written the same because they sound exactly the same. Thus semasiographies write synonyms identically; phonographies write homophones identically; and logographies write all words differently.

### 2.2.2.1 Representing Words and Morphemes: Logography

In a pure logography, a distinct character is invented for each morpheme of the language. Such characters are called logograms. We will give a technical definition for morpheme shortly, but as a first approximation we can think of logograms as representing words. The only system in substantial use nowadays that could even remotely be considered logographic in this sense is that of Chinese. In (11) the top line is a simple sentence written in simplified Chinese, the form of Chinese writing that predominates in most parts of the People's Republic of China. Characters are written with very little space between them, but with a bit of practice they can be readily isolated, because each character takes up the same amount of space. We add after the Chinese sentence an English translation, in single quotes. The second line in (11) separates the three characters. Under each character is written its Mandarin (standard Chinese) pronunciation in $p \bar{i} n y \bar{\imath} n$, a supplemental writing system that is widely used in the People's Republic, especially to help teach children to read. At this point, the phonetic values of the pīnyīn letters aren't important. The next line glosses each individual character by giving a representative translation into English. We've explained the structure of this example in some detail because similar
examples will occur throughout this chapter．The point of（11）is simply that each character represents a single word：
（11）我看报。＇I read newspapers．＇
我 看 报
wǒ kàn bào
I read newspaper

In some important respects，however，it isn＇t quite accurate to say that Chinese characters represent words．A better analysis is that characters rep－ resent morphemes．A morpheme is the smallest meaningful part of a word that in itself has a specific pronunciation and a specific meaning or function． Morphemes can be either simple words or significant parts of more complex words．Complex words fall into a few important categories，as illustrated by the English words in（12－14），where hyphens separate morphemes from each other． Compound words（12）are composed of two or more roots，morphemes that are themselves wordlike．Typically，the meaning of a compound word is suggested by the meaning of its components but is not fully predictable．Prefixes like un－ and suffixes like－able and－s modify words．In a process called lexical derivation， they may change a word＇s meaning or part of speech，effectively turning it into a different word（13）．Or，in a process called inflection，prefixes or suffixes may indicate some grammatical feature of a word，such as its tense or whether it is singular or plural（14），without changing its meaning or part of speech．
（12）green－house
（13）un－break－able
（14）cat－s
Similar principles apply to Chinese．Jiārén＇family＇（15）is one word，but it is written with two characters because it is a compound word with two mor－ phemes．The noun huàr＇painting＇（16）is derived from the verb huà by adding a suffix．The pronoun wǒmen＇we＇（17）is an inflected form of the pronoun wǒ， formed by adding a plural suffix．Each of these morphemes is represented by a separate character．
（15）家人＇family＇
家一人
jiā－rén
home－person
（16）画儿＇painting＇
画－儿
huà－r
paint（VERB）－NOUN
（17）我们＇we＇
我一们
wǒ－men
I－plural

Because a morpheme consists of both a pronunciation and a meaning，pro－ nunciations that are the same but have different meanings constitute differ－ ent morphemes and therefore are written with different Chinese characters （18－19）．By the same token，meanings that are the same but are associated with different pronunciations are different morphemes and so are expressed by dif－ ferent characters（20－21）：
（18）豹 bào＇leopard’
（19）报 bào＇newspaper＇
（20）二 èr＇two＇
（21）两 liǎng＇two＇
2．2．2．2 Representing Syllables：Syllabary
Unlike Chinese，the great majority of current writing systems are glotto－ graphic systems of the phonographic variety．That is，the systems use phono－ grams，which are characters that represent phonological units without regard to meaning．In a pure phonography，words that are pronounced alike are writ－ ten alike．Writing systems have adopted a number of options about how to break down words into sounds for purposes of spelling．This section discusses those systems that symbolize the syllable．

When breaking down language into its phonological components，that is， according to sound，people find it relatively easy to isolate the syllable．A syl－ labary is a phonographic writing system in which the characters are syllabo－ grams，each of which represents one syllable．One of the clearest examples of a modern syllabary is the Modern Yi writing system，which is used to write Yi languages，especially in Sìchuān，China．Every possible syllable in Yi is repre－ sented by a different character．The examples in（22－25）show four Yi syllabo－ grams along with their pronunciation in Yi pīnyīn．The exact pronunciation details are not important，except to understand that a consonant letter at the end of a syllable actually marks tone．For example，$t i t$ and $t i$ are pronounced the same，except that tit is pronounced with a high pitch of the voice and $t i$ with a medium pitch．As in the majority of languages of the world，differences in tone are often enough to distinguish two words．For example，tit，which has a high tone，can mean＇bite＇，but $t i$ ，which sounds the same except that it has a medium tone，can mean＇exchange＇．
（22）NB dit
（23）于 tit
（24）虫 ti
（25）］tat

These four characters were chosen to illustrate how different, unrelated characters are used in Yi even for syllables that have a lot in common. It isn't the case that a Yi syllabogram includes symbols for the consonants, vowels, and tones. Rather, as long as there is any difference at all between two syllables, completely unrelated characters are assigned to them.

An older version of Yi script was a logography $\left(\mathbb{\int} 2.2 .2 .1\right)$ that worked much like Chinese. But the modern writing system is a true syllabary. Being based solely on sounds, it writes all instances of the same syllable in the same way, regardless of meaning. The character in (22), for example, can be used to write the word dit that means 'dress somebody', the dit that means 'burn', the dit that means 'indigo pigment', as well as a few other homophones (SIL International and Southwest University for Nationalities, 2008). This is in stark contrast to a logography, which would have different characters for each of those morphemes. Consequently, a syllabary tends to have many fewer characters than a logography. Whereas the Chinese logography employs three to five thousand different characters for everyday use, the Yi syllabary has only 756 different basic characters.

Syllabaries are used for a handful of languages in addition to Yi. Cherokee in the United States and Vai, a language of Liberia, use syllabaries. And Japanese uses two different syllabaries, as we discuss in $\$ 2.2 .2 .5$, although in ordinary texts both are used in conjunction with logograms.

### 2.2.2.3 Representing Phonemes: Alphabetic Writing

An alternative approach to phonographic writing is to assign a unique character to each individual sound. These individual sounds are phones, the minimal (shortest) unit into which it is worthwhile to segment speech. Writing systems that have characters for individual sounds are called alphabets, and the individual characters in an alphabet are called letters.

The writing system used for Latin is a clear example of an alphabet (26):
(26) SONVS 'sound'
$\mathrm{S} \quad \mathrm{O} \quad \mathrm{N}$ V S
[s] [ว] [n] [v] [s]

The word pronounced [sכnus] is broken down into its individual phones, and each one is represented by a separate character. We annotate the sounds here by their symbols in the International Phonetic Alphabet (IPA), which is presented in the Symbols and Abbreviations section.

Our definition of the phone as the shortest worthwhile segment of speech is rather vague. Part of the reason for that vagueness is that it is sometimes difficult to decide exactly where segment boundaries should be. Consider the word blitz. English speakers consider blitz as having five phonemes: /blits/. But speakers of German, from which language the word was borrowed, consider
blitz to contain four phonemes. The words are pronounced the same in the two languages; the difference in how speakers analyze them is a matter of perspective. In English, /ts/ is treated as a plosive followed by a fricative (see the Symbols and Abbreviations section). In German, the same sound is treated as an affricate: a sort of plosive that has a slow, noisy, fricative-like release. This can be indicated in IPA by tying the two symbols together: /blits/. Although English treats /ts/ as being composed of two phones, it adopts a single-phone analysis for $/ \overline{\mathrm{t}} /$ as in chin. Writing systems often treat affricates as single, unanalyzed sounds, as English does when it uses «ch> rather than something like «tsh> for $/ \widetilde{\mathrm{t}} /$. Children who have not fully mastered the conventions of their language and writing system may produce incorrect spellings if they try to spell affricates as sequences of two phones, or two phones as an affricate.

A similar situation can occur with vowels. When two vowels come together in one syllable, forming a diphthong, writing systems may vary as to whether they are treated as two phones or one. English generally treats several diphthongs, such as [ar], as if they are single phones, potentially writing them with a single letter (27). Some other languages, such as Spanish, treat them as containing two phones (28), and write the letters that are appropriate for each of the two phones:
(27) my /mai/
(28) aire /aire/ 'air'

After the speech stream is broken down into phones, the next necessary step in any alphabetic writing system is to identify each phone with a particular letter. This is harder than it may seem, because in real life every phone a person utters is different in some respect from every other phone. The solution adopted by every known alphabet is that similar phones are assigned the same letter unless the difference between them is necessary for distinguishing some words in the language. That is, every letter in an alphabet is intended to be lexically contrastive. For example, we remarked earlier that in tone languages, such as Yi ( $\int_{2.2 .2 .2}$ ), the relative pitch at which a vowel is uttered can differentiate one word from another. This is never the case in English: Whether we say cat with a high pitch or a low pitch, it still refers to a cat, and the same is true of all other words. The Yi writing system assigns different characters when the vowels are of different pitch, because several different pitches (tones) are lexically contrastive in Yi. But it wouldn't make sense for English to do such a thing, because pitch isn't lexically contrastive in English.

To take another example, the words top (29) and pot (30) each have three phones in English. The first phone in top is pronounced with a puff of air called aspiration, which is symbolized by the superscript $\left\langle^{h}\right\rangle$. The last phone in pot, however, has no aspiration. Aspiration is important in English: If the aspiration were omitted in top, a native speaker would probably notice the omission. And yet aspiration isn't lexically contrastive. Speakers learn to always aspirate voiceless plosives like [t] at the beginnings of stressed syllables. Such
rules work the same for all words, and therefore they can't distinguish between words. A writing system for English can, and does, choose to lump together [t] and $\left[\mathrm{t}^{\mathrm{h}}\right]$. The system treats them as the same sound when it comes to assigning them a character, which turns out to be <t>:
(29) top: [t $\left.{ }^{\text {h }}\right],[\mathrm{a}],[\mathrm{p}]$
(30) pot: [ $\left.{ }^{\mathrm{h}}\right],[\mathrm{a}],[\mathrm{t}]$

In traditional linguistic theory, sets of phones that are lumped together as being similar and not lexically contrastive are called phonemes. Alphabetic writing systems assign individual letters to phonemes, not to phones. Phonemes, being sets of sounds, are abstractions of a sort. Sometimes the distinction between phones and phonemes is lost on native speakers of a language, for whom it may seem obvious that $\left[\mathrm{t}^{\mathrm{h}}\right]$ and [ t$]$ should be considered as somehow the same thing. The situation may be somewhat different for children who are learning to write, however.

The IPA provides a special notation for declaring that a pronunciation is transcribed at the level of phonemes: slashes. If top is transcribed with slashes, as in /tap/, that constitutes a promise that the IPA symbols represent phonemes in the language in question, and every phonetic symbol is guaranteed to be lexically contrastive with every other phonetic symbol. It would be a serious breach of trust to transcribe top pot as $/ \mathrm{t}^{\mathrm{h}} \mathrm{ap} \mathrm{p}^{\mathrm{h}} \mathrm{at} /$, because English has no lexical contrast between $\left[\mathrm{t}^{\mathrm{h}}\right]$ and $[\mathrm{t}]$ or between $\left[\mathrm{p}^{\mathrm{h}}\right]$ and $[\mathrm{p}]$. The square brackets can be used when we don't wish to make such a promise, or if we need to transcribe a sound in great detail, or if we know that we are talking about different allophones. The word allophone simply refers to different phones that are members of the same phoneme. For example, $\left[\mathrm{t}^{\mathrm{h}}\right]$ and $[\mathrm{t}]$ are allophones of the same phoneme in English.

As we will discuss in $\sqrt{ } 3.4$, it is hard for children to learn to analyze speech at the level of phonemes. This means that alphabets are somewhat harder to learn than they would appear to be to those of us who are fluent consumers and producers of alphabetic writing. But despite the fact that segmenting the speech stream down to the level of phones, not to mention resolving those phones into phonemes, is much more work than simply identifying syllables, alphabets are used by the vast majority of cultures for the vast majority of writing systems. Part of the reason for this wild popularity, no doubt, is historical chance. A few cultures that happened to possess alphabets were among the most prolific disseminators of literacy around the world, among them 'Islām, which spread the Arabic alphabet, and the Roman Empire and its European heirs, which spread the Latin alphabet. But a second reason for the success of alphabets must have to do with their learnability and usability. Languages only have a few dozen phonemes. Therefore, alphabets only have a few dozen characters that children must memorize. Once a child acquires the skill of segmenting speech into phones, an alphabet is easier than other systems, especially logographies ( $\$ 2.2 .2 .1)$. This claim is buttressed by the observation that most cultures that used to exclusively use Chinese logograms, such as

Việt Nam and Korea, now mainly use alphabets. Even in China, the pīnyīn alphabet plays an important role as a supplemental writing system.

### 2.2.2.4 Representing Subphonemic Features: Featural Writing

Because phonemes are, by definition, the smallest segment that speech can meaningfully be divided into, it doesn't seem reasonable that writing could divide up sounds more than alphabets do. But, while phonemes can't be divided into shorter units ( $\$ 2.2 .2 .3$ ), they can be divided into multiple features that occur at the same time. For example, the sound [p] has several distinctive features, including that it is labial (pronounced with the lips), a plosive, and voiceless (Symbols and Abbreviations section). Any phoneme in a language can be uniquely described in terms of what features it has. Might it pay off to directly represent these features in writing, instead of having unrelated characters for each phoneme? A language typically has fewer features than phonemes, which could make the system easier to learn.

The writing system that comes closest to implementing the idea of featural writing is Korean hangeul ( $\$ 1.1$ ). Both consonants and vowels have a high degree of systematicity in hangeul, but we consider here only the consonants. Table 2.1 shows most of the consonant letters of hangeul, arranged by their shape and accompanied by their pronunciation in IPA. Note how all the characters in a column build on the shape of the character at the top of the column. The different rows are derived by adding lines to that shape.

Inspecting Table 2.1 reveals several correlations between the graphical design elements of the characters and the phonetic features of the corresponding sounds (see Symbols and Abbreviations for definitions of these features). The characters in a particular column share a place of articulation: bilabial for the Square column, coronal (front of tongue) for the next two, and velar for the Right angle column. In addition, all the characters in the Wedge column are sibilants, hissing sounds. Patterns are also discernible in the rows. The Basic shape row contains mostly nasals. The next row comprises simple unaspirated plosives or affricates, and the bottom row comprises their aspirated counterparts.This is an impressive amount of regularity across several featural dimensions. Nevertheless, there is a lot of irregularity as well. The first column doesn't build its shapes in the same way as the other columns. The shape of the velar nasal (circular) doesn't connect it with the other velars, which have a right angle, and the fact that the /s/ character has a basic shape misleadingly places it with nasals.

It would have been easy to design a more transparently featural system than hangeul. However, the designers of hangeul made justifiable choices that fit well with the needs of writing's learners and users. Most of the exceptions to featural transparency make the characters simpler in shape and faster to write. The net effect is a set of characters that look like letters rather than bundles of characters for distinctive phonetic features. For all intents and purposes, hangeul is an alphabet, with several patterns that ensure that similar sounds mostly have similar-looking letters. Those similarities could be helpful for learners.
table 2.1 Hangeul Consonant Shapes

| SHAPE | SQUARE | LEFT ANGLE | WEDGE | RIGHT ANGLE | CIRCLE |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Basic | - m | ᄂ n | 人 S |  | $\bigcirc \mathrm{y}$ |
| + 1 line | $\bullet \mathrm{p}$ | ᄃ t | ᄃ $\mathrm{t}_{6}$ | $\neg \mathrm{k}$ |  |
| + 2 lines | 파 $\mathrm{p}^{\mathrm{h}}$ | $E \mathrm{t}^{\text {h }}$ | $E t c^{\text {h }}$ | $\Rightarrow \mathrm{k}^{\mathrm{h}}$ | $\overline{\mathrm{h}}$ |

### 2.2.2.5 Mixed Writing Systems

Up to this point in our discussion of what writing systems represent, we have illustrated each level of representation with a real writing system. When we talked about logographic systems, for example, we picked Chinese as an example ( $(\mathbb{2} 2.2 .2 .1)$. What we didn't say at the time is that no practical writing system follows one particular type of representation all the time. All writing systems are mixed, though some more so than others.

## Semasiography mixed with glottography.

Elements of semasiography ( $(\mathbb{2} 2.2 .1)$ are mixed into almost all glottographic systems ( $\$ 2.2 .2$ ). Almost universal is the use of numerals to represent numbers. It is quite unexceptional to see a figure like $£^{2,015}$ in the midst of glottographic text. More subtly, most aspects of punctuation and text organization (chapter 12) are semasiographic, representing our ideas about the logical organization of the ideas more than any property of language itself.

Logography mixed with syllabography.
Another type of mixing that occurs in writing systems is mixing of different types of glottograms. Chinese is basically a logography, as (31-32) illustrate. The example shows two different morphemes, both pronounced the same way, but with different meanings, so they are written with different logograms. But there are also quite a few instances in which characters are used mostly for their sound. New words and names have no established logograms in the script, so the most common solution is to use logograms for their sound value alone, essentially ignoring the meaning component. Thus Google is written as in (33) not because it is famous for its valley songs, but because the pronunciation of those characters sounds a lot like Google. This example involves a word that is not native to Chinese, but even native Chinese words can be spelled with characters that are used more for their sound than for their original meaning. Throughout Chinese history, it has been common to write morphemes with characters for similar-sounding morphemes, perhaps because a character was unknown to the writer or was simply hard to write. This process was accelerated greatly in the latter half of the 2oth century, when the People's Republic of China began a massive campaign to simplify its logography. Before the reform, there was a separate character for g$\check{u}$ meaning 'grain' (34), but it was decreed that that the character for ǧ̌ meaning 'valley' should replace it. Now the character that previously meant 'valley' means either 'valley' or 'grain', as if
it is being used for its sound value alone．Because almost all morphemes and therefore all characters are exactly one syllable long，the trend toward using logograms for their sound value makes Chinese writing appear increasingly syllabographic（ $\$ 2.2 .2 .2$ ），although very many true logographic contrasts such as（31）versus（32）still remain even in the simplified writing system．Many researchers prefer to call the Chinese writing system mor－ phosyllabic to reflect the fact that its characters represent both morphemes and syllables．
（31）谷 gǔ＇valley’
（32）古 gǔ＇ancient＇
（33）谷歌 ‘Google’
谷 歌
gǔ gē valley song
（34）穀 $\rightarrow$ 谷 gǔ＇grain’

Japanese：Logography mixed with semasiography and syllabography．
The Japanese language isn＇t known to be related to Chinese，but close cul－ tural contact led it to borrow the Chinese writing system．Thus the historical core of the Japanese writing system is a logography（ $\mathbb{2}$ 2．2．2．1）．Many Chinese logograms were borrowed with both their meanings and Chinese pronuncia－ tions，and the equivalence between the Chinese and Japanese is still identifi－ able even after more than a thousand years of language change（35）．To write native Japanese words，the usual solution was to co－opt a borrowed Chinese character（36）．Consequently，most characters in Japanese represent at least two different morphemes．
（35）水 sui（＝Chinese shuĭ）＇water＇
（36）水 mizu＇water＇
The fact that the great majority of Chinese characters in Japanese can repre－ sent multiple morphemes，as long as their meaning is the same，is much like semasiography（ $\mathbb{} 2.2 .1)$ ．Now，there can be no doubt that Japanese writing is a $^{2}$ true glottography（ $\$ 2.2 .2$ ）．Text in books is meant to be read as Japanese sen－ tences，and，crucially，the author means for the reader to realize each character in context as a specific morpheme with a specific pronunciation．So Japanese is a glottography with a good deal of homography（different morphemes written the same way），but it would be dishonest not to notice a hint of semasiography underlying all the homography．

Japanese has also developed two different syllabaries（ $\mathbb{2}$ 2．2．2．2）：katakana and hiragana．This led to an entirely different level of mixture in the Japanese writing system：The logograms，which are already somewhat mixed in that they have some features of semasiography，are used in conjunction with sylla－ bograms．The syllabograms are visually identifiable as a distinct set of charac－ ters，so much so that they are considered a separate script from the logograms，
unusual as it is for a single writing system to use multiple scripts．We focus here on hiragana，the syllabary that is used most frequently．Its basic syllabo－ grams are given in Table 2．2．

Any character in Table 2.2 is meant to be read with the onset phoneme named in the column header，followed by the vowel phoneme in the row label． Thus か represents $k a$ and あ represents $a$ ．Cells are left blank if the combina－ tion would represent syllables that don＇t occur in modern Japanese．As in the case of the Yi syllabary（ $\mathbb{2}_{2.2 .2 .2}$ ），there are no commonalities between the forms that share the same consonant or that share the same vowel．

Just a small fraction of the possible syllables of Japanese can be represented by basic syllabograms．Although there is a syllabogram for $k a$ ，for example， there are no syllabograms for the syllables kâ，kai，kan，kat，kya，ga，gan，or gya． Such syllables can be written by adding extra symbols to the symbol for $k a$ ， but they require the use of symbols that are not themselves syllabograms．For example，to write a syllable that ends in a nasal stop，a letter is added after the syllabogram（37）．

```
なん nan 'how many?’
な ん
na \(n\)
```

To represent a long vowel（indicated by a circumflex in Japanese translitera－ tion），an additional vowel symbol is written after a basic syllabogram（38）．
（38）つうき tûki＇ventilation’
つ う き
tu u ki

To represent voiced sounds like $d$ ，the diacritic（an auxiliary mark used to distingish sounds）＜＂＞is added to a syllabogram（39）．These sorts of extensions to the basic syllabograms allow Japanese to be written in almost perfect pho－ nological transcription，even though it has many times the number of syllables than are found in hiragana or katakana．
table 2．2 Hiragana

| VOWEL | ONSET CONSONANT |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | NONE | K | S | T | N | H | M | Y | R | w |
| a | あ | か | さ | た | な | は | ま | や | 5 | わ |
| i | い | き | し | ち | に | $ひ$ | み |  | り |  |
| u | う | ＜ | す | $\bigcirc$ | ぬ | 小 | む | ゆ | る |  |
| e | え | け | せ | て | ね | $へ$ | め |  | $れ$ |  |
| 0 | お | こ | そ | と | の | ほ | も | $よ$ | 3 |  |

```
どう dô 'how'
    ど う
    to-voiced U
```

Japanese could be written entirely in hiragana，and sometimes it is．In par－ ticular，hiragana is often used much as pīnyīn is for Chinese，as a supplemen－ tal script for children and anyone else who might have trouble with an obscure usage or character．In ordinary use，though，Japanese text mixes logographic and syllabic writing．

## Alphabet mixed with phonetic features．

In $\mathbb{\int 2 . 2 . 2 . 4 \text { ，we discussed how no full－fledged writing systems are completely }}$ featural．Korean hangeul comes closest，and it could be considered a featural system that took on characteristics of an alphabet．More commonly，what starts out to be an alphabet（ $\$ 2.2 .2 .3$ ）takes on featural aspects．This usually happens when an alphabetic writing system designed for one language is borrowed for use by another language that has phonemes not covered by the original alphabet．

We offer here several examples of how scripts based on the Latin alphabet have made modifications to suit their phonemic needs．In Spanish（40－41）， position of stress is important because it can distinguish words．Spanish marks the stressed vowel with an acute accent，whenever the presence of stress can＇t be inferred by other rules．（In IPA，stress is marked by the 〈＇＞symbol placed before the syllable containing the stressed vowel．）Thus the feature of stress is factored out and given its own symbol．
（40）término／＇termino／＇term＇
（41）terminó／termi＇no／＇he finished＇
Perhaps the purely alphabetic solution would have been to invent a series of new letters that represent the stressed version of each of the vowels．We don＇t know of any writing system that does that，however．It appears that certain features such as stress，tone，and vowel length are susceptible to being factored out and represented by distinct symbols．Part of the reason for that may be that the Latin script，on which most alphabetic writing systems are ultimately based，had no way of representing these features，and so people sought mini－ mally intrusive ways of adding them．Adding a diacritic seems to be a more dis－ creet change than inventing a series of new letters．But it is also worth noting that stress，tone，and vowel length are suprasegmental features，that is，features that function somewhat independently of the phoneme they are attached to and can even be thought of as being phonemes in their own right．Because of their semi－independent nature，it may be easy and natural for people to want to represent them by distinct featural symbols that combine freely with the letters that represent the more basic，segmental，phonemes．

The Vietnamese writing system provides a good example of how an alpha－ betic system can represent tone with separate symbols．All vowels with the
same tone get the same diacritic added to them, setting up a system of contrasts as in (42-43).
(42) vowels with low falling tone: à, ầ, ằ, è, ề, ì, ò, ồ, ờ, ù, ừ
(43) vowels with high rising tone: á, ấ, ắ, é, ế, í, ó, ố, ớ, ú, ư

Some alphabetic systems that have a contrast between short and long vowels indicate the latter by adding a second vowel, much as Japanese hiragana does. Another approach, taken by Hawaiian (44-45), is to represent the feature of length by a diacritic mark:
(44) short: a e iou
(45) long: $\bar{a}$ ē $\overline{1} \bar{o} \bar{u}$

Some alphabets have symbols for features that are not suprasegmental. Czech, like many Slavic languages, has a series of consonants that can be broadly classified as palatalized, that is, being pronounced with part of the tongue being closer to the hard palate than it is for simple, unpalatalized consonants. Because the basic Latin alphabet has nothing like this contrast in palatalization, the Czech alphabet has adopted a diacritic that indicates that feature. Letters with this diacritic are illustrated in (46), using the forms common in printing. In handwriting, all these letters typically are written with <̌> on top. In print, when that diacritic would make a letter appear too tall, an apostrophe is used instead.

## (46) č d'ň̌ řš tiž

Although we have been focusing on the representation of features in the Latin script, other alphabets also have symbols that represent features. Examples abound for the Arabic script, which has been adapted for use by many languages that are very different from Arabic in their phonology. Urdu, a language of Pakistan and India, differs from Arabic in that it has three retroflex consonants, which are distinguished from plain consonants in that the tongue is curled back farther. To represent them, a diacritic is added to the symbol for the plain consonant (47).
(47) $د / \mathrm{d} / \rightarrow \stackrel{\downarrow}{د} / \mathrm{d} /$

## Alphabet mixed with logography.

 along with ordinary letters. The ampersand $\langle \&\rangle$ is the most familiar logogram in English, standing for the word and.

Much more prevalent than the occasional pure logogram are cases where letters themselves are used in ways that are partially logographic. Standard abbreviations such as $D r$ for doctor or Mme for madame mix levels of representations. On the one hand, their origin as a string of letters that spell the phonemes of the words is undeniable. On the other hand, the letters in the
resultant abbreviation don't represent very many of the phonemes. Children must learn whether to use the full spelling or the abbreviation in various contexts on a word-by-word basis; this doesn't follow from general principles about how alphabetic writing works.

For some languages, the mixing of levels goes much further than a few conventions for the occasional abbreviations. In modern Greek, the sound /i/ can be written at least six different ways (48). The decision depends entirely on what morpheme a person wants to write. In (49), the last three vowels in the word are all /i/, but the letters are chosen because the stem /elin/ 'Greek' is always written with $\langle\eta$ 〉, the adjectival suffix $-/ \mathrm{ik} /$ with $\rangle$, and the inflectional ending -/i/ with $\langle\eta\rangle$-but only if the adjective modifies a singular noun with feminine gender. If it modifies a plural masculine noun (50), then /i/ is spelled as «ol>.
(48) Greek /i/: $\varepsilon ⿺, \eta, \mathrm{l}, \mathrm{ol}, \mathrm{v}, \mathrm{v}$
(49) $\varepsilon \lambda \lambda \eta \nu \iota \kappa \eta$ /elini'ci/ 'Greek' (adjective, feminine singular)

Spelling in Greek introduces several ways in which alphabetic writing can be complicated. The first issue is inconsistency in correspondences between phonemes and phonograms. If a system has a phonogram that can represent more than one type of phoneme, or if it has a phoneme that can be spelled with two different phonograms, there is an inconsistency. In modern writing systems such as Greek, the decision as to which letter to use to spell a sound is not decided by the writer's preference, but is determined by what word the writer is trying to spell. The spelling rules are deep, in the sense of the word introduced by Chomsky and Halle (1968). That is, the spelling can't be determined just by listening to the sounds of speech. It has to be determined in part by going somewhat deeper: by figuring out what words are represented and applying any special rules for spelling those words.

The principle of deep orthography may be clearest in the case of heterographic homophones-words that are spelled differently even though they have entirely the same pronunciation. Many examples can be found in deep orthographies such as English and French. For example, English spells in and inn differently, although both are pronounced as /mn/, and French spells point 'point' and poing 'fist' differently, although both are pronounced as /pw $\tilde{\varepsilon} /$. A tendency to differentiate homophones in spelling must be relatively weak, however. Many homophones are spelled alike, as in English bat (the flying creature) and bat (used to hit a baseball).

Another feature of deep orthography, in addition to a tendency to differentiate homophones in spelling, is morphemic constancy. This means that a morpheme is spelled the same way even if it is pronounced differently in different words. German, for example, has a rule that if a morpheme ends in $/ \mathrm{t}$ / in some words and /d/ in others, it should be spelled with a <d> in all cases (51-52). This makes German a little harder to spell, although in
principle it makes it easier for the reader to identify the morpheme that means 'dog'.
(51) Hund /hunt/ dog
(52) Hunde
/hund-ә/
dog-plural

Concepts such as deep orthography and morphemic constancy are relative terms. English is rightly considered one of the deepest of alphabetic orthographies. It has many spellings like damn, with a silent «n» that can only be explained in terms of morphemic constancy with respect to damnation, with its $<\mathrm{n}\rangle$ that is pronounced $/ \mathrm{n} /$. But it isn't nearly as deep as a logography like Chinese. Many words in English can be spelled by general rules that don't make reference to the component morphemes. In a true logography, every morpheme has an idiosyncratic representation in writing. And many words, even in the deep English orthography, don't show morphemic constancy at all. The same root that insists on its silent «n» in damn does not refuse to change its vowel in the closely related word condemn.

### 2.3 How Writing Represents Meaning

All writing is indirect. That is, writing isn't like a photograph. It is a system of signs, objects that refer to other objects. In order to learn about writing, therefore, children must learn how the signs of writing refer to what they represent. In what follows, we consider some of the ways in which this can happen. To do this, we draw on the work of Charles Sanders Peirce (Peirce, 1958). For our purposes, the most useful distinctions that Peirce made are those between icons, indices, and symbols.

### 2.3.1 How Semasiographies Represent Meaning

One of the types of signs that Peirce discussed is an icon. An icon works because it looks like the thing it represents. For example, is an iconic representation of fire. A person who had never seen this sign has a fighting chance of guessing its meaning. Iconic communication arose long before writing, and it remains important in modern times. People can use what they already know about an object or event to interpret the icon, and understanding doesn't depend on knowledge of any particular language. That immediate intuitive awareness, together with the wealth of detail that can be conveyed in a relatively small space, makes icons compelling. It has been suggested that children's earliest
hypotheses about how writing works is that it works like an iconic semasiog-


An index works because it is often associated with the thing it refers to. A semasiogram ( $\mathbb{\$ 2 . 2 . 1}$ ) might function indexically if a person always sees it written on the object it represents. Many people seem to have this relationship with the power toggle semasiogram (6, repeated as 53). It doesn't really look like power, so it isn't iconic. But people have seen it so often on the power switch of electronic equipment that they begin to understand what it means, by simple association.
(53) (l) 'power toggle'

A symbol works for some other reason than by being iconic or indexical. Perhaps a person has heard or read a definition of the symbol, or figured out what it means from other symbols it is used with. Although indexical and symbolic semasiograms might seem unimpressive when compared to the direct impact of an icon, there are good reasons for using them. A frequently used semasiogram might be both easier to write and quicker to recognize if it is relatively simple, even if that simplicity makes it less recognizable as a realistic image of a real-world object. In such a case, people's desire for economy of space and effort trumps the power of iconicity. We see this with numerals. Many times throughout history people have started off designing numerals on a purely iconic basis, with one simple sign, typically a line or dot, standing for the number 1 . They use two such signs for 2, three for 3, and so forth. We see this with the Roman numerals I, II, and III. When the numbers got big enough, however, people concluded that there can be such a thing as too much iconicity. They introduced conventional forms for larger numbers, such as $V$ for 5 and X for 10 .

### 2.3.2 How Glottographies Represent Meaning

Peirce's classification may be applicable to semasiographic writing ( $\$ 2.2 .1$ ), but does it apply to glottographic writing ( $\$ 2.2 .2$ )? In particular, is iconicity even possible in glottographic writing? Phonograms represent sounds, and these aren't easy to represent visually. Perhaps the writing system that has come closest to even attempting to represent speech sounds iconically is Korean hangeul (Table 2.1). As we noted earlier, the consonants are iconic in that they contain an element that shows the position of the articulators when the sound is made. The left angle element $\llcorner$ shows the tongue being raised in the front of the mouth (left side), and the right angle $\neg$ shows the back of the tongue being raised. Bilabial sounds are represented by the square $\square$ shape, which shows the opening of the mouth, suggesting the lips.

Sometimes glottographies represent certain suprasegmental features iconically. Korean has a set of consonants that are produced with extra tension in the vocal tract and are longer than other consonants. In modern hangeul, these
tense consonants are written by doubling the symbol for the corresponding lax consonant; for example, a lax $k$ is written $\neg$ and its tense counterpart is written $\urcorner\urcorner$. This doubling is an iconic way of showing that the consonants are longer: more writing representing more sound. It is common for Latin-based writing systems to represent long phonemes in this iconic fashion, perhaps because Latin did. Thus Italian contrasts short (54) and long (55) consonants through doubling:
(54) nono /'nono/ 'ninth'
(55) nonno /'non:o/ 'grandfather'

Tones comprise another suprasegmental feature that is often written iconically. In several languages, the acute accent $\langle\prime\rangle$ points upwards to mark a rising or high tone, and the grave accent ¿» points downwards for a falling or low tone. An example that we have already mentioned occurs in Vietnamese (42-43).

A different type of iconicity is found, though in a very indirect form, in the Greek, Cyrillic, and Latin alphabets. These alphabets derive from the Phoenician alphabet, whose letter names are mostly recognizable words, such as /me:m/ 'water' and / Ye:n/ 'eye' (56). And the shapes of the letters with those names do look like very simplified pictures of the items with those names. Thus one can see waves or ripples of water in the Phoenician letter named 'water', and a circle is quite a reasonable representation of an eye. In the Phoenician script, the letters represented the phoneme that stood at the beginning of the name for the item that was pictured. Thus an indirect iconicity prevailed, but one that was arguably useful for beginners learning the alphabet: If a child recognizes that $y$ looks like water, then just by naming 'water' in his language and taking its first phoneme, he will have worked out what sound the character represents. When Greek borrowed the Phoenician alphabet, it more or less kept the original names and sounds for each letter, without translating them. But even if a learner recognized that $y$ was a picture of water, that didn't help him recall the sound of the letter, because the Greek word for 'water' didn't begin with $/ \mathrm{m} /$. The same situation obtains in the modern writing systems that use scripts derived from Greek, including Latin and Cyrillic, because any connection between the name of what a letter shape pictures and the sound the letter represents is purely haphazard. The fact that the Spanish word for 'eye' (ojo) begins with an 〈 O 〉 is a nice coincidence, but that isolated fact doesn’t afford a child much help in learning the whole alphabet.
(56) Phoenician Latin
y /me:m/ 'water' M

- /Ye:n/ 'eye’ O

A form of iconicity also occurs for logograms ( $(\mathbb{2}$ 2.2.2.1). In some ancient languages, notably Egyptian as written in hieroglyphic script, logograms were often very iconic, such as the logogram for 'elder', a picture of an old man
leaning on a walking stick (57). In Chinese and Japanese, the writing systems that make the greatest use of logograms nowadays, the vast majority of logograms are not very iconic. Entirely representative is the Chinese logogram for 'elder', which also shows an old man leaning on a walking stick (58).

Egyptian 情
(58) Chinese 老 lǎo

Even if a Chinese character started out as iconic, as many did, it is conventionalized and abstracted. Characters have changed over time, too, to make them easier and quicker to produce. The net result is that Chinese characters are less iconic than many Westerners believe. In most cases, people who aren't familiar with them can't guess their meanings (Xiao \& Treiman, 2012).

Although the presence of a recognizable picture sometimes makes a character iconic, it doesn't always do so. The connection in meaning can be indirect, as in the Egyptian icon of a flag (59), which stands for a word meaning 'god'. After hearing the explanation that gods are worshipped in temples, and temples have flags, the connection makes perfect sense, and may serve as a mnemonic. But it is hard to argue that the character is truly an iconic representation of a god. Or, the connection can be via the sound of the word that names the item pictured. The logogram (60) can stand for a word meaning 'son', because the Egyptian word for 'son' sounded similar to the word for 'pintail duck'.
(59) 7 'god'
(6o) \} 'son'
To sum up our discussion of iconicity, semasiographies tend to have a lot of it and glottographies tend to have very little. Even in the case of logographies, where one imagines that there would be a lot of iconicity, cases where a logogram clearly pictures the object named by the morpheme the logogram represents are surprisingly rare.

### 2.4 Composition of Characters

In this section, we discuss how the characters of writing are composed-the visual units that they include. As we will see, characters are often made of recurring units that themselves have some meaning or phonetic function that contributes to the meaning or pronunciation of the whole character. This recycling of common graphic elements can make a set of characters more aesthetically coherent. It can also make the set easier for children to learn and remember by minimizing the number of elements that need to be learned.

### 2.4.1 Composing Semasiograms

Semasiograms ( $\$ 2.2 .1$ ) frequently combine existing elements. One well-known example is a convention for expressing prohibitions by putting a representation of the forbidden activity inside a red circle that has a slash through it (61-62). Such compositionality could potentially help children to produce the
correct symbol for a new concept．It helps them to guess the meaning of a sign they haven＇t seen before and also serves as a mnemonic for quickly retrieving the meaning of a known sign．
（61）$\bigcirc$＇Don＇t do it！＇
（62）＇no smoking＇
（63）＊＇no bicycle riding＇
Because the element（61）has a shape and function that recurs in different characters used in the semasiography of public signage，it is a functional graphic unit in that system．So are the other parts of these signs，such as ${ }_{\text {§ }}$ ＇smoking＇．

## 2．4．2 Composing Logograms

Among glottographies，logographies（ $\mathbb{2}$ 2．2．2．1）have the special problem that they require thousands of different characters．Composition can assist tremen－ dously in helping a few people create characters and in helping millions of others learn and recall them．

The great majority of Chinese logograms place two other characters next to each other in a way that makes it easy to take a composed character apart． Because Chinese requires all its characters to be the same size，the two compo－ nents are compressed．To illustrate with a logogram that we have used earlier， （64）shows how the word for＇home＇is composed from two other characters meaning＇building＇and＇pig＇．Apparently to the inventors of this character，it was very noteworthy that people kept pigs in or under their house．The little tree diagram is meant to show how the composition works from a logical point of view．The character at the top is composed of the two characters that are beneath it and connected to it by lines．

$$
\begin{gather*}
\text { 家 }  \tag{64}\\
\text { jiā } \\
\text { 'home' } \\
\text { '' }^{\prime} \text { '豕 } \\
\text { mián shǐ } \\
\text { 'building' 'pig' }
\end{gather*}
$$

The＇pig＇unit is composed of various parts such as a head（at the top）and legs （those parallel strokes on the left side），but those are just part of the pig picture， not functional units in their own right．

We have also mentioned the character for gē，which means＇song＇when it isn＇t part of Google＇s Chinese name．This character（65）shows how the process of composition can be recursive，in that one of the two characters of which 歌 is composed is itself composed of two other characters．It also illustrates a tack taken by the creators of the large majority of composed characters in Chinese． The creator of the logogram for $g \bar{e}$＇song＇wanted to suggest that the morpheme is like gé＇elder brother＇and also like qiàn＇blow＇．Usually one of the constituent
characters is picked because its morpheme sounds like the morpheme that the composed character represents. The other is picked because its morpheme has
 in that it is used solely for its meaning. Note that the meaning 'blow' is only vaguely related to the meaning 'sing'. The phonetic part is a type of syllabogram ( $\S 2.2 .2 .2$ ), in that it is intended only to suggest a syllable without regard to its meaning. It tends to be more specific than the semantic component, but by no means is it always an exact match for the word under consideration. This can be seen from the fact that the logogram for $g \bar{e}$ contains a component whose only function is to suggest that gē sounds like kě.


Readers can occasionally figure out what logogram a composed character represents by using the hints afforded by the constituent units. But it is much harder for a writer to guess how to write a morpheme just from drawing on her knowledge of how other characters have been composed in the past. Many of the phonetic and semantic associations used in composed characters aren't very systematic. They often rely on knowledge of literary or classical characters, meanings, and pronunciations, and young children may not possess this knowledge.

### 2.4.3 Composing Letters

It is obvious why it was useful to compose logograms from functional graphic units $(\sqrt{2} \cdot 4 \cdot 2)$. After all, languages need thousands of logograms, and people can benefit from hints as to how to interpret an individual logogram. Is there anything similar in syllabaries $(\sqrt{2.2 .2 .2})$ and alphabets $\left(\mathbb{} \mathbb{Z}_{2.2 .2 .3}\right)$, where the number of different characters is much smaller and consequently the stakes are not as high? That is, are phonograms ever built up from smaller functional units?

Yes, we have already mentioned characters like «ň in Czech, (46), which are composed of the functional unit $\langle\mathrm{n}\rangle$ and another functional unit representing palatalization. There are also less systematic ways that phonograms can be composed. For example, in French, diacritics were introduced to distinguish three different pronunciations of the letter «e» (66-68). Unlike the case of the Czech accents, none of these accents has a systematic meaning that extends across the alphabet.
(66) é /e/
(67) è $/ \varepsilon /$
(68) e/ə/

Another tack sometimes used to compose new phonograms is to join two letters together into one ligature．In a ligature，there is some visual clue that two letters are meant to be treated as one．For example，Old English introduced a new letter for expressing a sound intermediate between the sound of＜a＞and the sound of 〈e〉，by combining the two letters and writing them as «æ〉．

Czechs consider＜ch» a separate letter of their alphabet，and it even has its own rather surprising position in the alphabet，between $\langle\mathrm{h}\rangle$ and $\langle\mathrm{i}$ ．The moti－ vation for calling the «ch» a letter is that it represents a single phoneme，namely， $/ \mathrm{x} /$ ．That nomenclature isn＇t completely satisfactory，though，because in other ways «ch＞behaves like two letters．For example，«chléb»＇bread＇capitalizes to ＜Chléb»，exactly as one would expect from a sequence of the two letters «c» plus〈h〉．But it is undeniable that «ch» functions as a single phonogram in Czech．

English abounds in phonograms such as «ee» as a spelling for／i／（69）． Phonograms composed of multiple letters，which are called digraphs，raise spe－ cial issues in that there is no overt clue when two letters are to be taken as a unit．Sometimes＜ee» is a single functional graphic unit，sometimes it is a sequence of two functional graphic units（70）．
（69）r ee 1
l i 1
（70） reelect
x i $\partial 1 \varepsilon \mathrm{kt}$

## 2．5 Underrepresentation

Voltaire wrote that writing is＂the painting of voice；the closer it corresponds， the better it is＂（Voltaire，1764，as cited in Voltaire，2012，Essais）．But phonog－ raphies don＇t come close to living up to Voltaire＇s ideal．In this section，we discuss what writing leaves out．We argue that omitting detail often does no harm．Indeed，it can even help writers and readers．

Writing systems sometimes fail to represent certain aspects of a language， even certain distinctions that make a difference for meaning．Such underrep－ resentation is fairly common，for it fits with the writer＇s drive to save time and effort and it saves space as well．Writers want to economize，but they also want to achieve a satisfactory result：writing that can be read．Because underrepre－ sentation can be problematic for readers when it causes ambiguity，this means that it can go too far．

In alphabetic writing systems（ $\int 2.2 .2 .3$ ），the level of representation virtu－ ally never is more specific than the phoneme．For example，English writing doesn＇t have separate characters to distinguish unaspirated and aspirated／t／， because the difference never distinguishes words in English．Thus English writing underrepresents details about language that are heard in the voice but are unnecessary for accurate communication．Not representing these allo－ phones in detail may benefit children by giving them fewer characters to learn．

In other cases, writing systems leave out phonetic information that could be helpful to the reader. Consider the different ways one could vary the pitch and timing of words in the phrase "I'm OK" to make the sentence a straightforward declaration, or to convey uncertainty, or to suggest that the speaker is OK but other people may not be, or that the speaker is tolerably OK but could be a lot better, or to convey the opinion that the answer is in reply to a stupid question. These kinds of distinctions are conveyed by intonation: specific patterns of pitch and timing of phrases. We know of no writing systems that systematically differentiate the full range of intonation that people use in speech.

Intonation may be a special case of underrepresentation, in that it is a property of phrases and sentences and isn't necessary for telling one word from another. But many writing systems underrepresent even phonemic distinctions. Syllabaries ( $(\sqrt[2.2 .2 .2]{ })$ are particularly susceptible to underrepresentation. The Cherokee syllabary has 85 different characters, but the language has many times more syllable types than it has syllabograms. Therefore each syllabogram represents a range of syllable types that are similar to each other, but nevertheless phonemically different, capable of distinguishing words. In many cases, this can lead to homography, where a single spelling ambiguously represents two or more different words. Examples (71-74) show some representative cases. In Cherokee, unlike in English ( $\mathbb{2}$ 2.2.2.3) , differences in aspiration are phonemic (71). Nevertheless, most Cherokee syllabograms don't indicate whether the consonant is aspirated. Vowel length is phonemic (72), but the syllabograms don't indicate whether the vowel is long or short. There are also phonemic contrasts between tones (73)-we don't mark a tone when it is low-which are never indicated in the writing. Finally, (74) shows how the Cherokee script doesn't make any attempt to spell the glottal stop, /?/. Montgomery-Anderson (2008, from whom these examples were taken) listed 24 different pronunciations as being typical for each character. Despite such massive underrepresentation, a fluent speaker of Cherokee can access the correct pronunciation, because choosing the wrong pronunciation results in a nonword, or a word that makes no sense in context.
(71) dV ${ }^{\circ}$ 'S. /hatã: Jka / 'you did it' or /hathã: Jka / 'you hung it up'
(72) KAGJod /tsikowhthitha/ 'I am seeing it' or / tsi:kow ${ }^{\text {h }} \mathrm{t}^{\mathrm{h}} \mathrm{i} \uparrow \mathrm{ha}$ / 'I am seeing him/her'
(73) SO\& 0 OA /te: Inasu:le:sko/ 'we wash our hands' or /te:ไnasu:le:Tsko/ 'we take our pants off
(74) DL /ata/ 'wood' or /a?1ta/ 'young animal'

Perhaps syllabaries are driven to underrepresentation in order to keep the number of different syllabograms manageable. But alphabetic writing systems are also susceptible to underrepresentation of phonemic distinctions. English spelling fails to different the phonemes $/ \theta /$ and $/ \delta /$, a distinction of voice (75). Nor does English indicate which syllable is stressed (76). Hausa, a major language of Niger and Nigeria, has distinctions of vowel length and tone, but these aren't marked in the standard orthography (77). Tahitians rarely indicate
vowel length or the glottal stop when they write, even though these features distinguish words in their language (78).
(75) thin / $\theta \mathrm{m} /$ /vs. then / $\partial \mathrm{n} /$
(76) implant /rm'plænt/ verb or /'implænt/ noun
(77) daga /dá:gá:/ 'battle' or /dàgà/ 'from'
(78) ao / 2a?o/ 'fish fat' or /a:3o/ 'preach' or /a:o/ 'world'

The underrepresentation of length, tone, stress, and voicing is much more than one would expect of phonological features in general. There seems to be something special about the features that tend to be underrepresented. Most of these systematically underrepresented categories are suprasegmental. They may resist being represented for many of the same reasons that they are often written diacritically. Another explanation is that the differences between these sounds primarily has to do with activity in the vocal folds, and it is difficult if not impossible for people to feel what position their vocal folds are in when they make a sound. The word sets in (75-78) all feel pretty much the same when a writer sounds them out slowly and carefully, and indeed, features such as vowel length may get lost entirely when drawn out slowly. Such factors may not only retard the development of orthographic tools for representing these features but may also discourage writers from using such tools when they do exist. Thus, underrepresentation is not just economical for the writer but may reflect certain properties of the act of writing itself.

Several scripts that developed in Egypt and western Asia did not represent vowels, which is another case of underrepresentation. Among these was Phoenician, which was the ancestor of several modern alphabets that continue that practice in whole or in part: Arabic, Hebrew, Samaritan, and Syriac. Phoenician, during most of its existence, did not write any vowels at all. But it and its descendants came to write at least some vowels with letters that also represent consonants, typically consonants that are phonetically somewhat similar to the vowel being written. Example (79) shows a typical example, in modern Hebrew. Like Phoenician and Arabic, it is written from right to left. The first word, /jef/, is written without any vowels. The second word, /li/, writes the word-final /i/ with the same character that also represents the consonant $/ \mathrm{j} /$, as was seen in the first word. The third word has two /a/ vowels in it. The first is not written, but the last is written with a letter that can also represent the consonant /h/. In Arabic, generally, long vowels are represented by consonant letters, and short vowels aren't represented at all. Because the Arabic script was widely used as the basis for writing systems for several languages, this sort of pattern is rather widespread throughout the world.
(79) יש לי קסדה. H (jef li kasda/'I have a helmet.'

ישליקסד ה
hdskjlfj

Despite heavy use of consonant letters to represent vowels, many vowels are still unwritten or not fully distinguished in Arabic and Hebrew. Both languages have an adequate means of solving the problem of representing vowels: a system of diacritics called pointing. Thus while words with different vowels may be written identically in ordinary orthography (80), potentially causing difficulties for readers in some contexts, they can be easily distinguished by pointing (81-83). The solution is rarely used in general writing, although it is used very often in materials intended for children.

ברך /'berex/ 'knee’ or /ba'rax/ 'he knelt' or /be'rax/ 'he blessed'
(81) בֶּTֶ /'berex/ 'knee’
(82) בדַָּּ
(83) /Be'rax/ 'he blessed'

Thus, quite a few writing systems write all consonants but omit many instances of vowels, despite having alternatives for clearly writing all vowels. Many observers have sought explanations of why speakers of the languages in question tolerate, even prefer, writing without vowels. It is often pointed out that lexical derivation in Semitic languages such as Phoenician, Arabic, and Hebrew typically involves changing vowels, as in examples ( $80-83$ ). The claim, apparently, is that omitting vowels makes it easier to see the consonants that the derivatives all have in common. One also hears claims that, because these systems sometimes don't write vowels, they are profoundly different from alphabets, and need to be called by a different name, abjad (Daniels, 1996), which is the Arabic word for 'alphabet'. In our view, the fact that the characters of abjads encode phonemes makes them a kind of alphabet. The fact that they don't write all vowels is no different in principle from the other sorts of underrepresentation we have discussed in this section. It needs no explanation other than the fact that all these scripts descended from the same ancestor, Phoenician. Likewise, the fact that skilled users of Semitic languages prefer forms without pointing needs no explanation other than the fact that they are accustomed to these forms.

Many alphabetic scripts, especially in south Asia, use diacritics to represent vowels; these scripts are known as abugidas (Daniels, 1996). In almost all abugidas, there is an inherent vowel that writers indicate by writing no diacritic at all: underrepresentation. For example, in Bengali, a diacritic is added to a consonant symbol to show that the consonant is followed by a vowel such as $/ \mathrm{a} /$. This is illustrated in $(84 \mathrm{~b})$ for the consonant $6 / \mathrm{k} /$. But to indicate the vowel $/ \mathrm{J} /$, no diacritic is written (84a). Because the inherent vowel, in this case $/ \mathrm{J} /$, is generally the most common vowel in a language, not having to write it saves the writer a certain amount of ink and effort. However, the writer often has to pay for this convenience by being required to explicitly express the absence of a vowel in other cases. To unambiguously indicate that $/ \mathrm{k} /$ is followed by no vowel at all, one writes a special diacritic under the letter (84c). When two consonants come together in the same word, the consonant letters are fused together to show that there is no vowel between them. Example (84d) shows
the result of fusing the symbols for $/ \mathrm{k} /$ and $/ \mathrm{t} /$. The fusion shows there is no vowel between the consonants, but there is still an inherent / $\mathrm{J} /$ after the $/ \mathrm{kt} /$ cluster.
(84) a. ক/kJ/ (inherent /o/)
b. কা /ka/,কু /ku/, কে/ke/, কো /ko/
c. ক. /k/
d. ক্ত /kto/ from ক + ত /t/

### 2.6 Arranging Multiple Characters

So far, we have discussed the function and composition of the individual, basic characters of a writing system. But children must learn not just about individual characters but also about how to use them to build words and sentences. In this section, therefore, we turn our attention to the principles that writing systems have for arranging multiple characters. We begin by talking about the visual characteristics of text.

### 2.6.1 Lines and Pages of Text

In all writing systems, the units are arranged in an ordered sequence. They aren't randomly scattered over the page. This property, which we call sequentiality, is an attempt to map the temporal linearity of speech—the fact that speech can continue indefinitely in time-to the dimensions available to the writer. Regardless of the level of language that is represented, the sequentiality of writing is obvious from its presentation. Text has a train-like appearance that makes it quite distinct from most other two-dimensional displays, including pictures and maps. The elements almost always appear in an order consistent with the order they appear in speech. The most prominent exception is when vowels are written diacritically in abugidas $(\mathbb{\$} .5)$. A vowel that follows a consonant in speech may be written as a diacritic after, below, above, or before the symbol for the consonant; for some examples, consider Bengali (84b). In most abugidas, it is the exception rather than the rule for a vowel to be written in its natural temporal order, to the right of a consonant.

In principle, text could be sequenced in a variety of ways. A number of forms appear in ancient writings, some of which seem to have been intended to make each line of print as long as possible. For example, in the boustrophedon form (Greek 'ox turning'), the writer would line up characters across the writing surface, then turn 180 degrees and start writing them in the opposite direction, in effect making one long continuous line, as when plowing a field. All modern major writing systems have settled on the use of straight lines. That is, the text is rectilinear. We see oddly shaped lines only in special circumstances, such as lettering that curves around the edges of coins. With these rare exceptions, text is arranged either vertically or horizontally, parallel and perpendicular to
the edges of the writing surface. All modern writing systems have further concluded that the text need not be in one continuous line, as in former systems that used the boustrophedon form. If all of the text required for a page doesn't fit the width or length of the page, lines are broken at the edge of the page and the text resumes on a new line parallel to and in the same direction as the prior one. The use of a consistent direction from one line of text to the next allows users of the system to gain fluency with the chosen direction. Characters can be shaped in a way that helps the writer's hand and the reader's eye to move in that direction.

In the past, writing systems were often surprisingly tolerant of the direction in which text was written. A certain degree of toleration can be seen in some scripts even today. East Asian scripts were traditionally written from the top of the page downward, with new lines going to the left of prior lines. Now many of these scripts use both this traditional style and the Western style of horizontal writing. In general, however, most scripts have settled on a fixed direction for writing continuous text. For example, Mongolian uses vertical columns and Hebrew uses horizontal rows.

All modern writing systems, and most past ones, proceed from the top of the page to the bottom. People's attention seems to move more readily downward than upward, perhaps because objects fall much more often than they rise (Spalek \& Hammad, 2004). Moreover, when people write with something wet, like paint, writing in an upward direction would make smudging with the arm or sleeve more likely. Thus, there may be both cognitive and practical reasons for top-to-bottom directionality.

Some writing systems, like English, run their horizontal lines of text from left to right. In other cases, as with Hebrew and Arabic, the direction is right to left. The fact that writing systems have adopted both directions suggests that biomechanical and cognitive considerations don't favor one direction over the other to an appreciable degree.

### 2.6.2 Grouping of Characters

 regular, undifferentiated series along lines-scriptio continua. Chinese and Japanese are written without any spaces or marks between the individual characters, not even at word boundaries. Such writing captures the fact that spoken language is continuous, with no audible breaks between many of the words.

Many other writing systems group the linearized units in some way. This grouping is sometimes done via spaces, as in the many alphabetic scripts, including the Latin script, which use spaces between words. The practice has spread to other scripts, such as Korean hangeul, which until fairly recently used scriptio continua. Other systems, such as Ethiopia's Ge‘ez, use dots or vertical lines, rather than spaces, to mark divisions. In Hindi, most words are
written with a solid bar at the top that connects with that of the adjacent elements in the same word. The bar reinforces the impression that the word is a unit.

Widely used western scripts such as the Latin and Cyrillic don't normally group their elements into syllables. The chief exception is that division of a word, with hyphenation, at the end of a line of print is supposed to use syllable boundaries as one of its guiding principles. However, many other essentially alphabetic writing systems arrange their letters in secondary units that correspond, more or less, to syllables. Korean letters in a syllable are packed into square-shaped areas, which themselves are arranged rectilinearly (85). The syllable 한 Han is arranged with the first consonant and the vowel at the top and the final consonant at the bottom. The other alternative is illustrated by 국 gug, which arranges all three letters from top to bottom. The forms of Korean letters sometimes change when they are grouped together in a syllable, but the changes are rather minor. Although Korean imposes a syllabic organization on how it arranges letters, it is still an alphabet in that the individual phones are the primary phonological unit of consideration and the syllabic organization is secondary.
(85) 한국 Hangug ‘Korea’


In most of the south Asian abugida scripts, characters are grouped into bundles called akșaras. Example (86) shows, on the top line, a Sanskrit word written in Devanāgarī in the normal way. The next two lines show that word split apart into akṣaras, with the pronunciation of each akṣara in IPA. The last two lines show each of the akṣaras broken down into their functional components. Devanāgarī is an abugida ( $\mathbb{\int} 2.5$ ), so vowels are written with a diacritic, except for the inherent vowel (in Sanskrit, /ə/). Words are broken up after vowels, resulting in units that are syllable-like but don't necessarily follow the true syllabification of the word in question-here, /sã.juk.ta:k.sə.rəm/. When two or more consonants appear in the same akṣara, they have to be combined into a ligature, to prevent the reader from inserting the default vowel between them. The ligatures retain most of the essential properties of the component consonant characters. But some, such as क for $\boldsymbol{\sigma}+$ त, have more severe changes. A couple, such as क्ष for $\boldsymbol{\text { क }}+$ ष, are for all practical purposes arbitrary.
(86) संयुक्ताक्षरम् /sच̃jukta:ksərəm/ 'conjoined letter group'


Grouping into syllables sometimes conflicts with the tendency to respect morpheme boundaries．For instance，Korean saram＇person＇is written as two syllables（ 87 ）．When used as the subject of the sentence，the particle $i$ is added， resulting in sa－ra－mi．The $/ \mathrm{m} /$ is now in the third syllable，but continues to be written in the second syllable（88），in order not to change the appearance of the base word．That is，Korean sometimes deviates from its normal syllable group－ ing rules in order to maximize the extent to which the sounds of a morpheme are grouped together．Having to occasionally depart from syllables to recognize morphemes is likely to be difficult for spellers，but it could benefit readers．
사람 'person'
사 람
sa ram

```
사라ᄆ이 'person' subjECT
    사 라ᄆ 이
    sa ram i
```

Because writing lasts，in contrast to spoken language which naturally fades， the graphic side of writing takes on a life of its own．Many writing systems develop patterns that don＇t make sense except within the context of the graphic system itself．These patterns are graphotactic（Greek＇writing arrangement＇）．Hebrew，for example，has a series of words that are written attached to the following word， omitting the space that normally appears between words．These words include ／ha／＇the＇and ו／ve／＇and＇．The simplest explanation of why they are attached in this way is a graphotactic one：Hebrew words have to be at least two letters long． If a word is only a single letter，it is joined to the next one．Another example of a purely graphotactic pattern is that German，until very recently，resisted writing three identical letters in a row．Compound words are generally spelled by con－ catenating the spellings of the individual morphemes，but the compounding of Schiff＇ship＇and Fahrt＇voyage＇was Schiffahrt instead of Schiffahrt．

English，too，has patterns that are purely graphic in nature．One of them is that words normally don＇t end in 〈i＞，＜u＞，or $\langle v\rangle$ ．Another is that $\langle u\rangle,\langle v\rangle$ ，and ＜W〉 don＇t normally stand next to each other．These graphotactic rules explain several spellings and alternations that would otherwise be unexpected．For example，they explain why give and dove are spelled with a final «e» and why the vowel of work is spelled with $\langle 0\rangle$ instead of $\langle\mathbf{u}\rangle$ ．They also explain why English spells the stem of heaviness as «heavy»，not «heavi»．These graphic rules may be trumped by the tendency to spell loanwords as in their original language，which is discussed in the next section．Loanwords are words adopted from another language．So English has a few words such as ski，which was borrowed from Norwegian．Advertisers and ordinary people play with the graphic aspect of language when they use unusual spellings．The spelling 〈luv＞for love stands out，for example，not only because it isn＇t the conventional spelling for that word but also because it deviates from the graphotactics of English．

In some cases, graphic patterns arose from a need to avoid certain visually confusing sequences. This is one motivation for the English avoidance of 〈vv>, which looks much like 〈w $\rangle$. However, a more fundamental reason for the existence of purely graphic patterns is that writing lasts. Even though writing is meant as a sign, and even though it is meant to be important for what it represents rather than for what it looks like, people look at writing and not always through it. Voltaire's idea that writing's job is to represent language completely, which was discussed earlier, is thus wrong on two counts. First, writing isn't a full and complete transcription of language. Second, writing is a visual system of its own. As we will see in later chapters, children often learn about the outer properties of writing-what it looks like-before they learn how these patterns reflect the language itself.

### 2.7 Conservatism in Writing

Writing is conservative: It doesn't usually change quickly. This conservatism reflects, in part, the properties of its users. People value things that are familiar. Just as children come to love the people who take care of them and the foods they eat every day, so they come to value the things they have learned. Once people have learned something, especially something that is difficult or that is shared by many members of a society, they are reluctant to devote time and effort to changing it. Indeed, people become attached to the status quo and may begin to think that things couldn't have been any other way. The lure of the familiar is stronger for writing than for speech because writing lasts and speech fades. People don't usually know how words were pronounced a century ago, but they are more likely to know how those words were spelled. In the case of writing, conservatism is fostered by the fact that revered things from the past, such as a sacred scripture, could become harder to read if the writing system changed. The conservatism of writing means that we often read and spell using the standards of a somewhat earlier stage of the language.

The conservatism of writing is readily seen when a writing system was borrowed from one language and used for another language that was originally unwritten. Conservatism can lead to solutions that don't seem ideal for the borrowing language but that fit with what was done in the source language. For example, character shapes are often retained from the source language. Small modifications may be made, such as adding diacritics, but wholly new shapes aren't usually invented. In some cases, a borrowing writing system even keeps characters from the lending system that it doesn't need. The sounds represented by characters are also kept the same as much as possible. Rules may be borrowed that make sense in the source language but not in the borrowing language.

The conservatism of writing is also seen in situations in which a language that already has a writing system borrows words from another language. In many cases, the spelling is kept the same as in the source language, at least
at first. Retention of the original spelling means that the spelling of a word can provide a clue to language of origin. It also means that advertisers and product designers can create spellings that convey an impression of foreignness. The fast food restaurant that one of our relatives started, Joy of Junque, was named to convey the idea that the hamburgers and fries served at this restaurant were more sophisticated, more French, than those served at other restaurants.

The morphemic constancy ( $\mathbb{S}_{2.2 .2 .5}$ ) that now exists in English is in large part a side effect of conservatism. Latin had very little morphemic constancy: If a morpheme was pronounced differently in different words, it was spelled differently. When classical words were borrowed into English, a morpheme that in Latin might be pronounced the same in two different words, and hence spelled the same, might be pronounced differently in those two words when spoken with an English accent. Because Latin spelling was conserved, a morpheme would retain the same constant Latin spelling, even though that might now have two different English pronunciations. For example, the different pronunciations of the second vowel in impede and impediment are due entirely to English pronunciation rules. The Latin vowel was $/ \varepsilon /$ in both words, and so the spelling has the same Latin «e» in both words. Cases of this sort are very common. So it came about that, even though neither English nor Latin had earlier had a principle of morphemic constancy, English now does after its massive borrowing of Latin words.

Writing changes slowly over time, but it does change. For example, the spellings of loanwords tend to change to follow the patterns of the borrowing language as they come to be considered part of the language. German now mostly spells Cliché, which was borrowed from French, as Klischee, using the same spelling rules as used for native German words. In some societies, changes may be imposed by a formal body that sets standards for the language as a whole or standards for spellings to be used in specific situations, as in schools or in maps. Broad changes that affect many aspects of a writing system have sometimes occurred, as when Korea adopted hangeul, an alphabet that works quite differently from the traditional method of using Chinese characters. However, such changes are not all that common and are often opposed, reflecting the conservatism of writing.

### 2.8 Sound Change and its Effects on Writing

The different pace of change for spoken language and written language has many influences on how writing works and, by consequence, how children learn to use it. In particular, sound change in the absence of spelling change helps to explain many of the deviations from one-to-one correspondences between sounds and phonograms that occur in alphabetic writing systems. In order to understand the nature of these deviations, it is important to consider how and why sounds change.

### 2.8.1 Types of Sound Change

Sounds change for many reasons, many of which are not predictable or even explainable after the fact. But much sound change serves the function of helping talkers to achieve satisfactory communication with a minimum of time and effort. Talkers want to convey their messages quickly and easily, and they also want listeners to understand them. Economy of production can be fostered in many ways. These include changing phonemes into ones that require less effort to produce, omitting phonemes, modifying a sequence to permit an easier transition from one phoneme to the next, and overlapping the movements that are needed for production. Change can't go too far, however, because listeners need to understand. Understanding is best maintained when a new form is similar to the old one and contrasts between morphemes are maintained.

Some common types of sound change are illustrated with Spanish examples in (89-91). The word lobo used to be pronounced with a plosive /b/ (89), which totally blocked the flow of air out through the lips. Now it is pronounced as the approximant $[\beta]$, which is similar to [ w ] (see Symbols and Abbreviations for explanations of these phonetic terms). Changes that allow the air to flow more freely, such as this change from a plosive to an approximant, are considered weakenings of the original sound, and are easier to pronounce than the original sound. Another example of a weakening is when the /f/ sound turned into an /h/ as Latin transitioned into Old Spanish (90). An ultimate weakening is deletion, as when even the $/ \mathrm{h} /$ sound disappeared, so that nowadays the word for 'son' is simply /ixo/. Also very common is assimilation, where a sound changes to become more like another sound which is nearby, typically adjacent. Spanish is similar to many other languages in that an original $/ \mathrm{k} /$ sound, as found in the original Latin /ke:na/, changed to become pronounced more forward in the mouth, ultimately as $/ \mathrm{s} /$ in many dialects (91). This change happened in words where the $/ \mathrm{k} /$ came before vowels that are pronounced in the front of the mouth, such as /e:/. This assimilatory change made the transition between the consonant and the vowel easier for the speaker.
(89) lobo 'wolf': /b/ > /ß/
(90) hijo 'son': /f/ (Latin filius) $>/ \mathrm{h} />\varnothing$
(91) cena 'dinner': /k/ (Latin) $>/ \mathrm{s} /$

Sound change usually affects a number of words at the same time. Thus Spanish /b/ became / $\beta$ / not just in lobo but also in abrir 'open', pueblo 'people', cabeza 'head', and hundreds of other words. Sound change is regular in the sense that a single general rule can tell us what happened across the vocabulary of a language. If a sound changed in all words across the board, it is said to be unconditioned. The deletion of /h/ in Spanish (90) is an unconditioned change: It happened in all words that had an $/ \mathrm{h} /$. Many other changes are conditioned, in that they happen only when the sounds in question are in a particular phonetic environment. Thus the change of [b] to [ $\beta$ ] (89) is conditioned
because it only happens to instances of [b] that follow certain sounds, principally vowels. In an expression like " $\mathfrak{B B u e n o ! " , ~ w h e r e ~ [ b ] ~ o c c u r s ~ a t ~ t h e ~ b e g i n - ~}$ ning of a sentence, the change doesn't take place. Assimilations, by definition, are conditioned changes as well.

Sound changes don't occur in a vacuum. If a sound $X$ changes into a sound Y that already exists in the language, X and Y are said to have merged. For example, in Nigerian English, all instances of $/ \theta /$ changed to $/ \mathrm{t} /$, a sound that already exists in English, with the result that both thin and tin are pronounced the same, /tm/: / $\theta /$ merged with $/ \mathrm{t} /$. Deletions have an effect much like a merger. After English deleted $/ \mathrm{k} /$ before $/ \mathrm{n} /$ at the beginning of words, words like knight and night sounded the same; one could say that $/ \mathrm{k} /$ merged with nothingness before $/ \mathrm{n} /$. If a sound X changes only under some conditions into a sound Y , X is said to have split into X and Y . An example of a split occurred in many forms of English when vowels such as $/ \varepsilon /$ became long before voiced obstruents such as /d/ (e.g., bed) but not before voiceless sounds (e.g., bet): / $\varepsilon /$ split into short [ $\varepsilon$ ] and long [ $\varepsilon:$ ]. It is also common for a sound change to combine two of these categories. A Latin sound change that is still noticeable in modern English loanwords changed /s/ to /r/ when between vowels. This led to pairs like justice versus juridical, where the root meaning 'law' appears with an «s» before a consonant but with an «r» between vowels. Here, the conditioned change resulted in /s/ splitting into /s/ and /r/, with the latter merging with the $/ r /$ that already existed in Latin.

### 2.8.2 Effects of Sound Change on Writing

Sound changes may have a great impact on writing, or they may have none at all, depending on whether they affect the system of phonemes in a language. Some mergers and splits affect only allophones of one phoneme, as in the case of English vowel lengthening. The new long vowels as in bed [be:d] are just allophones of the previously existing short vowel, allophones that fluent speakers and readers automatically produce based on the identity of the next consonant. Because $[\varepsilon:]$ and $[\varepsilon]$ are incapable of distinguishing words by themselves, there is no reason for the writing system to develop a new symbol to denote the difference.

Other changes can have a much bigger impact. Consider the case where Nigerian English $/ \theta /$ merged with $/ \mathrm{t} /(\mathbb{} 2.8 .1)$. After that change, all words that originally had the phoneme $/ \theta /$ now had the phoneme $/ \mathrm{t} /$. A true phonographic writing system should update the spelling so that any word previously spelled with the phonogram for $/ \theta /-<$ th>-should henceforth be spelled with the phonogram for $/ \mathrm{t} /$ - <t>. However, writing systems don't usually update their spellings as soon as there has been a sound change. Updating an orthography after a sound change can take centuries. In the meantime, with the orthography effectively representing the language as it used to be pronounced, the mismatch between spelling and current pronunciation leads to some complexities in the orthography. We describe the nature of these complexities in
this section, and we also describe why they usually affect spellers more than readers.

One complexity that is often caused by sound change is inconsistency in the mappings between phonemes and phonograms. After the Nigerian English merger of $/ \theta$ / with $/ t /$, Nigerians must learn that $/ t /$ is spelled «th> in some words, like thin, and $\rangle$ in other words, like tin. In contrast, the Nigerian reader only has to learn two phonogram-to-phoneme rules: «t> is pronounced /t/ and <th > is pronounced /t/. These two rules have no more exceptions than their counterparts had before the sound change. The effects of merger are thus more detrimental for spellers than for readers.

As we noted earlier, deletions are mergers with nothingness, and they disadvantage spellers in the same way as other mergers. Consider the case of Spanish dropping the /h/ sound, which was spelled $\langle\mathrm{h}\rangle$. A reader has no trouble seeing $\langle\mathrm{h}\rangle$ and saying nothing. She learns a simple phonogram-to-phoneme rule: 〈 h$\rangle$ is silent. A speller writing a word that begins with a vowel has no way of knowing whether the word used to contain $/ \mathrm{h} /$, and so has to memorize the set of words that are spelled with 〈h>.

The examples just given involve unconditioned change, but similar phenomena occur in the case of conditioned changes. In the southern United States, the phoneme $/ \varepsilon /$ merged with $/ \mathrm{I} /$, but only if the next sound in the word was a nasal. Thus ten changed from /ten/ to /tin/, but /bed/ didn't change to /bid/. The southern reader has no problem reading a word like ten correctly because he can effectively apply the sound change that led to the merger: The « n » still remains in the word as a cue to change apparent $/ \varepsilon /$ to $/ \mathrm{I} /$. The southern speller, in contrast, can't undo a merger. So the fact that he pronounces a word as /tin/ doesn't tell him whether the earlier pronunciation, on which the spelling is based, was $/ \mathrm{t} \mathrm{t}$ / or $/ \mathrm{tm} /$. The same problem is true of conditioned deletion, or merger with nothingness. English deleted the velar stops, $/ \mathrm{k} /$ and $/ \mathrm{g} /$, from the beginning of words when the next sound was $/ \mathrm{n} /$. It is easy for the reader to replay that rule and not pronounce the consonant at the beginning of «knot> or «gnat>. It is impossible for the speller to play the merger backwards and know whether a word beginning with /n/ originally had $/ \mathrm{k} /$ or $/ \mathrm{g} /$ at the beginning. Instead, the speller has to remember which words are spelled with «kn» and «gn».

To summarize the discussion so far, sound change unaccompanied by spelling reform leads to inconsistencies in both reading and writing. A phonogram may have multiple pronunciations, and a phoneme may have multiple spellings. If a sound change constitutes a merger, the effect on spelling is much greater than the effect on reading, typically entailing much memorization on a word-by-word basis.

A pure split, one that doesn't involve a merger, would give the advantage to the speller rather than to the reader. Such a sound change would introduce a new phoneme into the language, which is by no means an everyday occurrence. But one clear case of a split that favors spellers over readers is the split of the Middle English phoneme $/ \theta /$ into two phonemes: $/ \theta /$ and $/ \delta /$. The
spelling «th＞wasn＇t changed．Consequently a speller only needs to learn two exceptionless phoneme－to－phonogram rules－／$\theta /$ is spelled «th＞and $/ \delta /$ is spelled «th＞－whereas a reader must learn many tricks for decoding «th＞in words like then versus thin or ether versus either．

Because so many sound changes are conditioned，writing systems that don＇t change to keep up with the spoken language will tend to have many conditioned spellings．Because $/ \mathrm{k} /$ changed to／s／before «e〉 or 〈i〉 in the his－ tory of Spanish，but the spelling «c＞was retained regardless of whether $/ \mathrm{k} /$ changed，the spelling rule is conditioned．Because merger was，as usual， involved—Spanish already had an／s／sound—reading is easier than spelling． A reader who sees «cena＞＇dinner＇can replay the historical sound change and know for sure that the word is pronounced／sena／．A speller，who starts with the pronunciation，doesn＇t in principle know whether this／s／was originally $/ \mathrm{k} /$ or $/ \mathrm{s} /$ ，and therefore whether it should be spelled as 〈c〉 or 〈s $\rangle$ ．Importantly， however，the condition itself isn＇t necessarily subject to any merger：The same conditioning environment may be found after the sound change as before it． Consequently，the speller knows that «c＞is a possible spelling of／s／in a word like／sena／，which still has the／e／after the／s／，but that 〈c〉 isn＇t a possible spelling of／s／in a word like／sopa／＇soup＇，where the vowel would not have caused the sound change．A speller who takes context into account may not be guaranteed the correct spelling，but the probability of getting the correct spelling will be better than if the context isn＇t taken into account．Moreover， readers may be able to understand misspellings that take context into account better than they would understand misspellings that violate contextual condi－ tions．For example，if a Spanish child spelled semilla／se＇mija／＇seed＇as＜cemi－ lla＞，most adults would readily understand what the child meant．If the child spelled／sopa／as＜copa＞，ignoring the rule that 〈c＞is a possible spelling of ／s／only before／e／or／i／，a reader，who follows the regular conditioned rules that reading affords，would read that production as／kopa／．The reader would either fail to understand the child＇s intent or judge the spelling to be very bad．

Another common result of keeping spelling constant in the face of sound change，in addition to inconsistency and conditioned rules，is that the writing system will take on certain aspects of logographic writing（ $\$ 2.2 .2 .5)$ ．This hap－ pens because a writer will often need to take into account what morpheme she wants to write in order to spell its sounds correctly．To spell the sequence ／sen／in Spanish，for example，it is necessary to take into account whether it is the morpheme that means＇dinner＇or the morpheme that means＇breast＇ as in seno／seno／．Having decided the former，one knows that the spelling is with a «c＞，because all words with that morpheme are spelled with a＜c»， including cena＇dinner＇，cenar＇to dine＇，and cenaduría＇diner＇．That is，all things being equal，there will be a certain amount of morphemic constancy．From the speller＇s present－day perspective，it looks as if the writing system is intention－ ally assigning different spellings to homophonous morphemes．However，it is more accurate to say that conservative writing systems spell morphemes as they used to be pronounced．Given the amount of merger that happens in the
history of a language, it isn't surprising that a certain number of homophone pairs would have been pronounced differently in the past, when the spelling conventions were established.

In addition to its implications for the writing system itself, sound change has some sociological implications. Sound change begins in a specific time and place, typically among young adults. It then takes some time to spread to the rest of the language community, if it does at all. As a result, the writing system may in some respects more closely match some speakers' language than others. For example, in much of the English-speaking world, /h/ has been deleted before /w/, so that words like which and whale, originally /hwit $\widetilde{\mathrm{J}} /$ and /hwel/, came to be pronounced /wiţ/ and /wel/, just like witch and wail. For people who speak such dialects, the phoneme-to-phonogram mapping for /w/ is now inconsistent: It is never clear when to spell «w and when to spell <wh». But for people in Scotland, where that sound change is much less prevalent, there is no such homophony. It is obvious to them that «wh> should be used if the pronunciation is /hw/. In that respect at least, English orthography seems more consistent and logical to them than it does to, say, Americans. By the same token, spelling may be more consistent for older members of a speech community who have not adopted sound changes popular among younger speakers. But there is arguably an advantage to everyone's using the same spellings regardless of their age or residence.

### 2.9 Which Language Do We Write?

Writing represents language, but which language? Up to now we have written about language as a single, ideal entity. But that is rarely the case. Not only are writing systems standardized, but the language one chooses to write is standardized as well. Or, at least, communities tend to have opinions about what language it is most appropriate to write in. A child who isn't familiar with the preferred language for writing, therefore, may have difficulty learning to spell.

Finnish is famous for having one of the most regular writing systems. It represents phonemes with utmost consistency and almost no conditioned rules. However, the language one speaks isn't necessarily the language one writes. In normal, colloquial speech, a Finn would normally pronounce the inflected form of the word talo 'house' that means 'in the house' as /talos/. However, the conventional spelling is talossa. The spelling corresponds to a pronunciation that is normally used in rather formal styles of speech. The spelling is perfectly regular, but only if the speller already knows the more formal pronunciations and knows to use them when writing. It is quite common for the standard written form of a language to be based on more formal spoken forms, which may differ substantially from the colloquial speech that children acquire outside of school. In extreme cases, the standard language and the colloquial language are so different that they could easily be considered separate languages. Examples include standard French versus Kreyòl in

Haiti, and Modern Standard Arabic versus the local dialects throughout the Arabic-speaking world.

No matter how easy the writing system may be per se, writing well may be quite complicated if one in effect first has to master another dialect. In English, it is hard to say which dialect's speakers would have the greatest advantage in spelling. The spelling system is reasonably dialect neutral, in part because the system was put in place centuries before the most differentiating local sound changes occurred. For many other languages, it is more obvious that the writing standard has crystallized around the speech of a certain area, often the capital of the country.

In some cases, writing well is easy only if one literally has mastered a foreign language. As mentioned earlier, languages often write loanwords in the original spelling system. In some cases, all of a writing system's irregularity may come from loanwords, and the total amount may be considerable. The basic spelling system of Yiddish, which uses the same right-to-left script as Hebrew, is highly regular. But Yiddish has borrowed hundreds of words from Hebrew and Aramaic, always retaining the spelling the word had in the original language. Hebrew adds a good deal of inconsistency to Yiddish, both because Hebrew is rather inconsistent in its own right and also because some of its spelling patterns differ from those of Yiddish. In the core Yiddish system, for example, /s/ is always spelled 0 (92). But if the word in question comes from Hebrew, two additional possibilities present themselves: $ש$ (93) and $ת$ (94). This inconsistency is a complication. However, if one is already literate in Hebrew, as many Yiddish speakers are, the requirement to spell such words as they appear in Hebrew seems quite natural. It might in fact be easier to handle than the task of respelling the words in accordance with Yiddish rules.
(92) סקאֵלפּ/skalp/ 'scalp'
(93) שימחה/simxe/ 'party'
(94) (Sabes/ 'Sabbath’

English is analogous in that it has its own basic spelling system—albeit not as consistent as that of Yiddish-and has complicated it considerably by borrowing an extremely large number of words from other languages, especially Old French, Latin, and Greek. The original spellings of the words influenced their spelling in English, especially during the Renaissance, when it became de rigueur to spell most Latin words in a close approximation of their classical spellings. Greek words were often written in Greek script, but eventually writers settled on writing them in the Latin script, using transcription conventions developed by the ancient Romans. This incorporation of foreign spellings has led to a number of complications. Spellings that were completely regular in classical Latin became inconsistent after two thousand years of sound change. For example, cell /sel/ is quite easy to spell if one knows the word comes from the Latin word cella /kella/. However, for a child who doesn't know Latin and its rules such as those mapping /k/ to <c>, the choice of how to spell /s/and whether to use single or double $<\gg$ can seem quite difficult.

Given this history, Carney (1994), expanding on an analysis put forth by Albrow (1972), described English spellings as belonging to several different systems: basic, Romance, Latinate, Greek, French, and exotic. These systems correspond more or less to the languages the words were borrowed from, or to the existing system on which new words like photography were based. Basic words tend to be native words like bind and tooth, which have been passed down from the earliest Germanic invaders of Britain; these words are typically short. The basic system also includes many words that were borrowed into English, such as all the Scandinavian loanwords like give and skin that date back to the Old English period. The Romance system includes mainly words that were borrowed from French during the Middle English period: words like villain and pleasure. It differs from the French system in that the latter is based on more recent loans that preserve modern elements of French pronunciation and spelling, such as quiche and genre. The Latinate and Greek systems apply to words that mostly maintain Latin and Greek spelling, such as Latinate opprobrium and Greek rhinoceros. Words in the Latinate and Greek systems tend to be relatively long. The exotic system is a grab bag for recent loans from other languages, such as Afrikaans trek and Italian cello. All of these systems have spelling rules of their own. For example, /k/ before <i> is spelled «k> in basic words (king), «ch» in Greek words (chiropractor), and «qu> in French words (quiche). Not all spellings are so divergent, though. For the spelling of /f/, only Greek is an outlier (philosophy is Greek, as against Latin favor, French folie, and so forth). Many other sounds are normally spelled the same way in all systems. Moreover, although language origin is a major factor in determining what spelling rules apply in English, it isn't the only factor. If a word's pronunciation has changed markedly from its original form, it tends to be treated as a basic word. For example, chair was borrowed from Old French, which got it from Latin, which got it from Greek cathedra. But nothing of that long heritage is reflected in its basic spelling patterns.

### 2.10 Conclusions

A picture is worth a thousand words, but that is precisely the problem with it for permanent communication: A picture doesn't stand for a particular unit of language. Writing does. The glottographic nature of writing allows it to express any and all thought, as language does. This is a major benefit. However, our discussion of the nature of glottographic writing systems suggests that learning these systems isn't easy. Children must isolate the relevant units from the speech stream, which can be difficult to do because their forms often change when they are embedded in speech. They must classify these units in the same way that the writing system does. They must know or learn the specific language that is represented in writing, which may differ in some ways from the language they normally speak. They must deal with the fact that writing may not represent certain aspects of the language itself, such as intonation.

Children must also deal with the fact that, as a result of sound change and other factors, the links between units of language and units of writing may be complex.

Many of the patterns in writing reflect the structure of the language that the writing system represents. However, because these patterns appear on the surface of writing, in the order and arrangement of the symbols, children could potentially learn about them on a graphic basis. In addition, as we have discussed, many writing systems have patterns that are purely graphic in nature. By learning about the outer form of writing, children could potentially begin learning about its inner workings.

Our discussion of the nature of writing systems provides one foundation stone for an understanding of how children learn to produce writing. A second foundation stone for understanding how children learn to produce writing is an understanding of human learning. We turn in chapter 3 to this topic.

## CHAPTER 3 <br> Learning and Teaching

to understand how a system is learned-whether it be chess, algebra, or writing-one must understand the nature of the system. One must also understand the nature of the system's learners. Having discussed the characteristics of writing systems in chapter 2 , we turn in this chapter to the nature of learning. One goal of the present chapter is to lay out some basic principles of human learning and to briefly preview what they may mean for the learning of writing. Writing developed relatively recently in human history and in some groups of people but not in others. This makes it highly unlikely that people would have evolved learning mechanisms that are specific to writing. Children use the cognitive mechanisms that they already possess when learning about a writing system, and so it is important to understand the nature of these mechanisms.

When learning about writing, children use not only their general-purpose learning skills but also their knowledge of language. A second goal of this chapter, therefore, is to review some aspects of spoken language development. As we discuss, children learn to speak and understand beginning very early in life, and written language is learned later. We consider some of the reasons for and consequences of this difference during the course of the chapter.

Learning and teaching are intertwined. A third goal of this chapter is to consider some general ways in which children's environment can be structured so as to aid learning. We discuss both informal teaching methods-those that draw learners' attention to important aspects of a situation in unobtrusive and often nonverbal ways-and formal teaching methods, such as explicit discussions about the workings of a system. The present chapter's discussion of formal and informal teaching sets the stage for discussions, in later chapters, of teaching about specific areas of orthography.

### 3.1 Statistical Learning

The world is somewhat predictable: Things that have often happened before tend to happen again. Children take advantage of this predictability by learning how often events occur and how often and under what circumstances they co-occur. In this way, they develop a kind of mental statistics that helps them to deal with the environment.

The ability to learn about the frequencies of events and combinations of events based on exposure to them is present from infancy, and it is seen across a variety of domains. For example, babies as young as 2 months old, when exposed to sequences of colored shapes, can learn whether a green triangle is more likely to be followed by a yellow circle than by a pink diamond (Kirkham, Slemmer, \& Johnson, 2002). Statistical learning has also been documented with speech. For example, 8-month-old infants, when exposed to streams of syllables in a miniature artificial language, can learn that/bi/ is more likely to be followed by /da/ than by /ku/ (Saffran, Aslin, \& Newport, 1996). Infants learn not only about associations within a sensory modality but also associations that cross modalities. For example, babies who are just a few hours old can learn that a rattling noise occurs when one toy is visible but not when a different toy is visible (Morrongiello, Fenwick, \& Chance, 1998).

Children pick up many patterns in their environments through statistical learning, even when the patterns are probabilistic rather than deterministic rules, that is, all-or-none rules that always give the correct answer. Consider a phonological property of personal names in English: Female names are more likely to end with / $\partial /$ than male names. Three-to five-year-old children take advantage of this phonological cue when they judge Stoka to be an appropriate name for a female doll and Stokat a more suitable name for a male doll (Cassidy, Kelly, \& Sharoni, 1999). Surface cues to categories such as male names and female names make the categories less arbitrary. One need not learn purely by rote that Rebecca is female and Brett is male; one can use the phonological cues in the names. This strategy works well in many cases, but not for the disc jockey who said "Now hear one of my favorite selections by George Gershwin, with lyrics by his lovely wife, Ira" (Goffman, 1981, p. 255). In fact, Ira was George's brother.

In some cases, an event or sequence of events is common in some situations but is rare in others. For example, cars are frequently observed driving on the right sides of roads in the United States but are rarely observed driving on the right sides of roads in England. As another example, the letter sequence <sS> is fairly common in the middles of Finnish words, but it never occurs at the beginnings. Patterns such as these, which depend on context, are called conditioned patterns. Those that don't depend on context are unconditioned patterns. A conditioned pattern may be highly reliable, as is the association between country-United States versus England—and side of the road on which vehicles drive-right versus left. Even when conditioned patterns have no exceptions, however, people are slower to learn them than to learn
unconditioned patterns (Warker \& Dell, 2006). One reason for the difference is that learning that an item or a sequence occurs often in some contexts interferes with or makes it harder to learn that it is uncommon in other contexts.

In laboratory studies of statistical learning, researchers often arbitrarily select certain items or combinations of items to be presented more often than others. Conditioning factors, if present, are also arbitrary. In real life, there are often reasons why some items and combinations of items are more frequent than others. For example, the fact that fewer English words begin with $/ \mathrm{ki} /$ than would be expected based on the individual frequencies of $/ \mathrm{k} /$ and $/ \mathrm{i}$ / reflects the fact that the entire body of the tongue would have to quickly slide forward to transition between those two phonemes. The sequence /si/, which requires a shorter movement and which is more economical to produce, is in English more common than anticipated based on the frequencies of its elements (Kessler \& Treiman, 1997). In other situations, one piece of information about frequency may be arbitrary but other pieces of information become less arbitrary when the first piece is known. For example, a speaker of English who has learned that $/ \mathrm{t} \mathrm{t} /$ is more common than $/ \mathrm{tw}$ / may find it relatively easy to learn, based on the similarity between /t/ and /d/, that / $\mathrm{d} \mathrm{I} /$ is more common than /dw/ (Goldrick, 2004). That is, old knowledge helps in the acquisition of new knowledge.

People often use contiguity as a cue that two items are related to one another. This probably reflects the fact that things that are adjacent to one another in space or time are more likely to be causally related to one another than more distant ones. Thus, infants and adults find it easier to learn about the frequencies of adjacent items than of nonadjacent items (Gómez \& Maye, 2005; Newport \& Aslin, 2004). As Gestalt psychologists pointed out, items that are not only adjacent to one another but also physically connected to one another are especially likely to be treated as a group. This helps to explain why, under some conditions, people are more likely to learn about the frequency with which two shapes co-occur if the shapes are physically joined to one another than if they aren't (Baker, Olson, \& Behrmann, 2004). Similarity also plays a role in learning about co-occurrence. Thus, people learn about dependencies between nonadjacent items more easily when the items are similar to one another and the intervening elements are different than when this isn't so (Newport \& Aslin, 2004). Given the nature of the world, it is often items that are contiguous, connected, or similar that are associated with one another. When this isn't the case, people tend to be slow in learning about the associations.

Because children can't be sure in advance which events will be associated with one another or which conditioning factors will prove to be important, they often spread their attention widely. Consider the French girl who hears chat 'cat' on a cold day when her stomach hurts and when she is watching an animal stroll across a grassy field. She next hears the word on a warm day when she is feeling happy and well and when she is watching an animal sleep in the sun. The weather is different, the child's mood is different, but the type of animal
is the same. Across situations, the girl observes, the word chat co-occurs with the animal, which turns out to be its true referent, more often than with other potential referents. Children can detect co-occurrence more easily if they perceive and remember many aspects of a situation: the weather, the objects in the scene, their mood. Because beginners often spread their attention widely, they may learn about nonessential aspects of a situation as well as or even better than essential aspects. Consider the child who, after an excursion to the zoo, remembered the sparkly stones in the zoo's sidewalks better than most of the animals. As children become familiar with a domain, they increasingly direct their attention toward cues that have been relevant in the past. Such narrowing of attention is beneficial if the environment remains the same. However, it may cause problems if the environment changes.

Knowledge about the statistics of the environment benefits children in many ways. It helps to reduce the effort that must be expended for perception, since less information needs to be taken in to confirm that an expected event occurred than to perceive an unexpected event. Knowledge about statistics also helps people to compensate for limitations in their memories. When a child has forgotten the details of a birthday party, for example, she may be able to determine what happened based on her knowledge about what typically occurs at such parties. That is, memory is constructive rather than always veridical. Another benefit of statistical learning is that it allows people to treat common sequences of events as chunks. For example, children can remember the spoken word /bəg/bug as a combination of /b/ plus the chunk/əg/, which is familiar as a rime in other words such as rug, in addition to as a string of $/ \mathrm{b} /$, $/ \partial /$, and $/ \mathrm{g} /$. This redundancy benefits memory. Chunking has advantages for production as well. For example, the motor program that is required to produce the common sequence / $\partial \mathrm{g} /$ can be run off as a unit. As we will see in later chapters, statistical learning plays an important role in learning about the symbols of writing and how they connect to language.

Although statistical knowledge helps people to deal with probable events, it can cause them to modify improbable ones to make them better fit the patterns in a domain. For example, people may reverse the order of two items in a memorized string when the reversed order yields a more common pattern than the presented order (Botvinick \& Bylsma, 2005). Regularization errors of this sort occur because people revert to what is most probable based on past experience when memory or perception is faulty or incomplete. Research discussed in later chapters reveals that children sometimes regularize spellings as well.

### 3.2 Learning Through Language

Statistical learning through exposure to individual instances requires many observations. For example, a child may see one bird flying on Tuesday and a different bird flying on Thursday. After many observations of many different
birds，the child may learn that most birds are able to fly．Children can poten－ tially acquire generalizable knowledge more quickly by means of language （Csibra \＆Gergely，2009）．For example，if a father utters the generic state－ ment＂Birds fly＂while pointing to a bird，his child can potentially learn that the ability to fly is characteristic of birds in general，not just one bird at one point in time．Learning general information from a statement such as＂birds fly＂requires a degree of linguistic skill that isn＇t available to infants．By about $2^{1 ⁄ 2}$ years of age，though，children are knowledgeable enough language users to recognize the difference in meaning between a generic statement such as ＂Birds fly＂and a specific statement such as＂That bird is flying＂（Graham， Nayer，\＆Gelman，2011）．A teacher who says＂ 0 ＞＞s are round＂or＂／z／is spelled with 〈z〉＂is providing general information，just like a father who says＂Birds fly．＂Generic statements often gloss over exceptions：Not all birds fly and not all ／z／s are spelled with＜z＞．

Language can inform children about properties that characterize classes of items，and it can also draw children＇s attention to properties that they might otherwise overlook．Thus，children who hear other people call different－looking items by the same name，such as $/ \varepsilon \mathrm{m} /$ for both＜m＞and 〈M ，may search for similarities among the items that they hadn＇t previously noticed．Children who hear different labels for similar items may search for differences among the items．For example，terms like powder and hardpack may draw attention to differences among types of snow，perhaps encouraging people to form finer categories that they would have otherwise．Indeed，linguists such as Whorf and Sapir claimed that language shapes people＇s ideas about the world （Whorf，1956）．A strong version of the hypothesis put forward by Sapir and Whorf is probably incorrect：People can notice the difference between powdery snow and hard snow even if they don＇t have different nouns for them．But a weaker version of the hypothesis－that the distinctions made by language heighten people＇s attention to certain distinctions in the world－may be cor－ rect（Roberson，Davidoff，Davies，\＆Shapiro，2005）．

## 3．3 Implicit and Explicit Knowledge

We have argued that people，even very young ones，pick up many patterns in the world through statistical learning．Much of this knowledge is implicit，in the sense that it is tacit and hard to verbalize．For example，children who have learned about the statistics of their environment may respond more quickly or more accurately to a common event than an uncommon one，and they may be able to predict，above the level expected by chance，the next event in a sequence．However，people may be unable to report on the structure that drives their behavior，sometimes even denying that a pattern exists（Cleeremans \＆McClelland，1991）．When people do provide verbal reports about what they know implicitly，those reports may be incomplete or inaccurate．Other knowledge is explicit：People know they know and can easily verbalize their
knowledge. Explicit knowledge guides many aspects of teaching and learning, and so it is important to consider its nature.

From an early age, children want to know why things are the way they are. They seek out explanations from other people, they attempt to articulate explanations themselves, and they argue about whose explanations are better. People's reports about why the world works as it does tend to be crisp and categorical. The reports may not capture the multiple influences that are in fact at work. Consider the boy who asked his mother from the backseat of a car "Why do only dads drive?" He failed to notice that, as he was asking the question, his mother was driving. This boy had observed, accurately, that his father drove the family's car more than his mother did. However, the explicit theory that the boy had developed treated the choice of a driver as an all-or-none matter that depends only a person's sex rather than a probabilistic matter that depends on multiple factors. The theories that grown-up scientists develop often focus on a small number of factors as well. They, like the boy, sometimes overlook data that contradict their theories.

People's ideas about the reasons for their own behavior may be biased as well. In some cases, these ideas are based not primarily on veridical introspection but on what seems plausible (Nisbett \& Wilson, 1977). For example, a young man whose heart pounds as he crosses a scary suspension bridge and who is approached by an attractive woman may attribute the pounding of his heart to attraction to the woman rather than to fear. Given this attribution, he is more likely to attempt to contact the woman later than a man who is approached by the same woman while he is crossing a bridge that doesn't sway (Dutton \& Aron, 1974). As another example, consider an experiment in which people heard sentences that were embedded in noise. The participants judged that the background noise was softer if they had heard non-noisy versions of the sentences earlier in the experiment than if they hadn't (Jacoby, Allan, Collins, \& Larwill, 1988). That is, the participants attributed the ease that they felt with the repeated sentences to a contemporary cause (soft background noise) rather than to an event that was separated in time (earlier exposure to the sentences).

Children and adults who are asked to make explicit judgments about what they know and do often overestimate their abilities. In one study, for example, 4 -year-olds predicted that they would be able to throw 7 of 10 balls into a container, more than the 4 or 5 balls they actually managed (Schneider, 1998). In some situations, as when an individual is asked whether she knows a certain fact or a certain spelling, overconfidence in part reflects the fact that the person makes her judgment based on the information that is available to her at the time. The available information includes the correct answer, and this inflates the person's estimates of her knowledge (Metcalfe, 1998). Children's overconfidence may also reflect the fact that adults sometimes tell them they have performed well and protect them from the negative consequences that might otherwise follow errors. Overconfidence has a positive side: A child who thinks that she is already fairly good at a task and that she will improve quickly is
motivated to perform the task. But overconfidence has a negative side: A child may stop practicing before she has fully mastered a task, thinking that she is already highly skilled. Overconfident people may attribute their failures to lack of luck rather than lack of skill. They may not seek outside help or corrective feedback, and they may ignore, discount, or misinterpret any feedback that is provided. As we will see in later chapters, overconfidence occurs in spelling, as in other tasks.

The considerations we have been discussing help to explain the conservatism that children and adults often show. People attribute the ease that they feel when performing a well-practiced task to the nature of the material: It must be correct; it must be easy; it must make sense. However, that feeling of ease may actually reflect the large amount of practice that people have had with the task. People's conservatism may mean that they come to think of arbitrary and unmotivated facts and associations as reasonable and logical. "Even if I don't understand the reasons behind something," a child may think, "adults do". This feeling that things are sensible can make people reluctant to accept change. Thus, children who have learned the spoken words sun and moon may believe that there is a reason why one word must go with one referent and the other word with the other. They think that the words couldn't be switched even if everyone agreed to do so (Piaget, 1929). Children who have learned a spelling, too, are reluctant to change it (Downing et al., 1984). Familiar things come to seem attractive as well as sensible (Bornstein, 1989; Reber, Schwarz, \& Winkielman, 2004), making people even more reluctant to change them. For example, people in England think that the name Richard sounds nicer than the name Fulbert because they are more familiar with it (Colman, Hargreaves, \& Sluckin, 1981).

Well-practiced material can come to seem so easy that people may think that they knew it all along, even when they didn't (Sanna \& Schwarz, 2007). This feeling can make it hard for adults to understand that children might not know the material. As Kelley and Jacoby (1990, p. 57) stated, "When teaching material that we have long-since mastered, our subjective experience is a poor basis for predicting students' difficulty: We may experience the material as simple and the students as dull-witted." Such feelings can make it hard for experienced spellers to teach children who know little about the system.

### 3.4 Learning of Language and Learning About Language

So far, we have been discussing learning as it occurs in a variety of domains. However, any type of organism learns some things more easily than others. For example, humans more readily learn to fear snakes than to fear flowers (Öhman \& Mineka, 2001). Rats more readily learn to avoid a taste that has been paired with poison than to avoid a combination of clicks and flashes that has been paired with poison (Garcia \& Koelling, 1966). Humans, too, are quick to learn that eating a certain food is associated with later nausea (Bernstein
\& Webster, 1980). As these phenomena show, evolution has prepared organisms to learn about poisonous snakes and noxious foods-things that affect survival.

Language is important for human survival. All human societies have a language, and infants come into the world prepared to learn it. Indeed, children may even invent a rudimentary language when no conventional language is accessible to them, as with deaf children whose hearing parents don't use a signed language and who develop their own signs (Goldin-Meadow \& Feldman, 1977). Whereas a spoken or signed language is primarily a product of biological evolution, writing is primarily a cultural achievement. Learning to speak and understand is more natural for children than learning to read and write, just as learning to associate nausea with a food is more natural than learning to associate nausea with a pattern of lights and sounds.

Given the importance of spoken language as a basis for written language, and given that literacy is learned in part through language, we turn now to a discussion of spoken language learning. In all cultures, that learning begins very early in life. Spoken language is conveyed through variations in the frequency, loudness, and other properties of sound waves, and infants find these sound waves interesting. They pay more attention to human speech than to monkey vocalizations, human coughs, or dripping water (Schultz \& Vouloumanos, 2010). Indeed, infants will suck on a nipple that doesn't give milk in order to hear a human voice, but they won't do so in order to hear a musical instrument (Cairns \& Butterfield, 1975). Parents in many societies speak in a singsong manner when talking to infants, and infants find this form of speech to be particularly attractive (Cooper \& Aslin, 1990).

During the first months of life, infants can recognize the fine acoustic differences that distinguish pairs of syllables such as [ba] and [da] or [xa] and [la], even when the differences don't serve to distinguish meaning in the language to which the infants are exposed. For example, 6 - to 8 -month-old infants who hear only English at home can discriminate two consonants that differ in their place of articulation-dental [t] versus retroflex [t]-even though those sounds aren't different phonemes in English. But by the age of 10 to 12 months, those infants begin to have difficulty distinguishing those sounds, as do English-speaking adults, who perceive them both as allophones of the English phoneme /t/. In contrast, infants who hear Hindi at home-a language in which those two phones are different phonemes, capable of distinguishing words-never lose the ability to distinguish the two phones (Werker \& Tees, 1984). Even before they can say meaningful words, then, infants' perception has been shaped by their language experience. Further evidence of early learning about speech comes from the finding that, somewhere between around 6 and 10 months of age, US infants begin to learn that English disyllabic words are more likely to begin with a stressed syllable (e.g., apple) than an unstressed syllable (e.g., guitar; Jusczyk, Cutler, \& Redanz, 1993).

Infants become familiar with the phonological forms of some common words before they know much, if anything, about the words' meanings. As
early as $4^{1 / 2}$ months of age, for example, infants have some familiarity with the phonological form of one especially frequent and personally important word, their given name, and they prefer to listen to their name than to other names (Mandel, Jusczyk, \& Pisoni, 1995). Early knowledge about the phonological forms of words may be incomplete, however. For example, Corey may know enough about the sound pattern of his name to allow him to rule out Lucy and Nicole, but he might accept the similar-sounding Cora. Learning about phonological forms of words is facilitated not only by frequent exposure to the word but also by spaced (distributed) presentations rather than massed presentations (Cepeda, Pashler, Vul, Wixted, \& Rohrer, 2006; Schwartz \& Terrell, 1983). In addition, children are better at learning short words than long words and better at learning words that contain common rather than uncommon sound sequences (Storkel, 2001, 2004).

Children learn not only about the phonological forms of words but also about the links between the phonological forms and the words' referents. These links are usually arbitrary. For example, there is no principled reason why a cat is called /kæt/ in English and why a cow is called /kav/. Nonarbitrary links could potentially aid the learning process, as motivated associations are generally easier to learn than arbitrary ones. However, only a small minority of words in any language are phonetically iconic, in that the word resembles a sound that is associated with the word's referent. Phonetic iconicity does sometimes occur in words for sounds and in words for objects that make distinctive sounds. For example, the Japanese /ki/ and the French /bip/, which contain vowels that have a high-pitched overtone, designate high-pitched sounds. Another example of phonetic iconicity involves the words for sounds that animals make. In many languages, including English, Turkish, and Hungarian, the word for the sound a cow makes starts with [m]. The words for the animal itself are rather different in these languages, however, and none of them begins with [m]. Moreover, many languages have at least a few words that imitate the sound made by the object those words refer to. For example, the cuckoo bird is named after its call. Although children could use phonetic iconicity to help learn a few words, it isn't helpful for the great majority of words, including cat and cow.

Even though the associations between words and their referents are usually arbitrary, children begin to learn some of these associations starting around the end of their first year or the beginning of their second year of life. The number of words that children can produce and understand grows rapidly, with 16 -month-olds reported to understand around 150 different words (Fenson et al., 1994) and 6-year-olds around 10,000 (Anglin, Miller, \& Wakefield, 1993).

The learning of vocabulary, like the learning of language in general, benefits from the fact that children hear language virtually every waking hour. In one study, the parents of US children between about 1 and 3 years of age spoke an average of 1,440 words per hour to their children (Hart \& Risley, 1995). Considering that parents also talk with other people within earshot of their children, and considering that even young children can learn words from
speech that they overhear (Floor \& Akhtar, 2006), this means children have a huge amount of spoken language input.

Several other factors, in addition to the sheer amount of language input, contribute to the speed of vocabulary learning. One contributing factor is that the linguistic context in which a word occurs can often provide a clue to its meaning. For example, a 2 -year-old may know that yellow refers to a color, based on the fact that she has heard the word as an answer to questions such as "What color is it?" However, the child might not know which specific color yellow refers to (Sandhofer \& Smith, 1999). Vocabulary learning benefits, too, from the physical and social context in which it occurs. An adult may name an object when it is prominently in view and when both the child and the adult are looking directly at it, and these conditions help the child learn to map the word to its referent (Baldwin et al., 1996; Yu \& Smith, 2012). Moreover, even though the associations between individual words and their referents are usually arbitrary, words in certain categories may be phonologically similar to one another. For example, as mentioned earlier, female names in English are more likely to end in / $\partial /$ than male names (see Monaghan, Christiansen, \& Chater, 2007, for other examples of phonological differences between classes of words in English and other languages). Children may take advantage of these similarities when learning words.

In many languages, vocabulary learning benefits from the fact that new words may contain meaningful parts that the learner already knows ( $(\mathbb{2}$.2.2.1). For example, a child who has never heard the compound word birdhouse may be able to deduce from its component morphemes that it's a place where birds live. A child who has never said leopards may do so if she knows that the inflectional suffix -s is added to nouns to indicate plurality. Children form some words via compounding and inflection at an early age. Even 2 -year-olds sometimes produce novel compounds, as when one child said firedog to refer to a dog found at the site of a fire (Clark, 1981). The children in another study were proficient at using the present progressive inflection -ing and the plural inflection before their third birthday (R. Brown, 1973). However, young children have some difficulty with words that are irregularly inflected. They sometimes produce regularization errors as in "My teacher holded the baby rabbits and we patted them" (Cazden, 1972, p. 92). Indeed, even adults are faster at producing regular past tense forms than exceptional (or irregular) past tense forms: an example of a regularity effect (Cortese, Balota, Sergent-Marshall, Buckner, \& Gold, 2006; Tabak, Schreuder, \& Baayen, 2010).

Although even young children know a good deal about inflectional morphology and compounding, many aspects of derivational morphology are rather difficult. For example, some US 9- and 10-year-olds who know the meaning of celebrate can't guess what celebratory might mean (Tyler \& Nagy, 1989). However, broad statements about the relative difficulty of different morphological devices mask large differences within each category. For example, English-speaking children learn to form nouns with agentive -er (naming a person who does a particular action, e.g., teacher) and
adjectives with $-\gamma$ (e.g., cloud $\gamma$ ) before they learn about many other derivations (Derwing, 1976).

People's tendency to analyze words is such that they sometimes find morphological structure that didn't originally exist. For example, hurricane is a single-morpheme word that was borrowed from Spanish huracán, but people often interpret the first two syllables as being the English word hurry, as befits the hurricane's fast winds. This interpretation seems to have even influenced the spelling.

As we mentioned in $\mathbb{\int 2 . 9}$, the vocabularies of some languages include words of different origins that follow different types of spelling patterns. English-speaking children tend to learn words from the basic system (e.g., tooth) first. Indeed, written materials that are designed for young children contain few if any words from the Latinate (e.g., opprobrium) and Greek (e.g., stochastic) systems (Corson, 1982). Clearly, children can't begin learning about the spelling rules that apply to words in these categories until they are exposed to a number of such words. Children's knowledge of words of Latin and Greek origin increases as they approach adolescence. In one study of oral language, 15 -year-olds used over twice as many words of Latin and Greek origin as did 12-year-olds (Corson, 1982).

Learning of language involves not only learning about words and morphemes but also learning about how they combine to form sentences and phrases. Children begin combining words into short strings around the age of $1^{1 / 2}$ years, and their early strings may deviate markedly from the adult grammar. As children get older, they begin to produce and understand more complex sentences. Whereas a 2 -year-old may ask whether a ball hit Mommy's purse by asking "Hit Mommy purse?", a 3- or 4-year-old may ask "Did the ball hit Mommy's purse?"

Learning to speak and understand a first language, we have seen, is rather rapid. Learning about language, or developing linguistic awareness, is slow and difficult. Speech is fleeting. Its ephemeral nature makes it hard for children to attend to speech as an object, outside the meaning that it conveys. Phonemes are especially difficult to bring to awareness, lacking as they do an objective phonetic correlate. Thus, children who don't know an alphabetic script tend to perform poorly on phonemic analysis tasks that require them to count, delete, or compare phonemes. For example, young children may have difficulty judging that /bet/ bet contains three units of sound or that its first unit is the same as the first unit of /blu/ blue. Children tend to perform better on formally similar tasks that involve larger units, such as syllables (Goikoetxea, 2005; Liberman, Shankweiler, Fischer, \& Carter, 1974; Treiman \& Zukowski, 1991). Adults who don't know an alphabetic script, either because they know a logographic writing system ( $\$ 2.2 .2 .1$ ) or because they are illiterate, also tend to perform poorly on phonemic analysis tasks (Bertelson, de Gelder, Tfouni, \& Morais, 1989; de Gelder, Vroomen, \& Bertelson, 1993). Alphabetically illiterate adults, like preliterate children, tend to perform better on explicit tasks that involve large phonological units than on tasks that involve smaller units.

For example, these adults may be able to delete /a/ from /a'fu/, because it constitutes an entire syllable in that pseudoword, but may be unable to delete the phoneme /f/ from /fux/, where it is only part of a syllable. The position of a linguistic unit in a word is another influence on accessibility, in addition to linguistic level. For example, it is easier for children to determine that plank and prove begin with the same phoneme than to determine that spit and float end with the same phoneme (Treiman \& Zukowski, 1991).

Writing isn't part of the human genetic endowment in the way that spoken language is, and learning about writing involves a degree of explicit linguistic knowledge that goes beyond learning to speak and understand. Moreover, there are many hours during a young child's day during which he or she sees little or no written language or ignores what writing is present-many more such hours for written language than for spoken language. These considerations suggest that children will not generally learn to write and read as early or as naturally as they learn to speak and understand. Systematic teaching is usually required in the case of written language.

### 3.5 Formal and Informal Teaching

We turn in this section to the question of how the environment can be structured in order to aid learning, considering principles of teaching that apply across a variety of domains. We briefly preview some of the implications of these principles for spelling instruction in this section. Detailed discussions of this topic are saved for the later chapters that take up specific aspects of learning to spell.

In order to learn about something, children should be exposed to it and should attend to it. For example, people learn best when they focus on the material to be learned rather than dividing their attention between it and other things (Toro, Sinnett, \& Soto-Faraco, 2005). One way to encourage learning, therefore, is to ensure that children are exposed to and attend to the material. This can be a challenge in the case of writing: Humans aren't built to find print interesting in the way that they are built to find speech interesting.

The input that is provided to children can be modified in order to make learning easier. For example, children who are learning the Latin alphabet see forms such as «b» and «h», with relatively tall lines on the left, and forms such as « n », with short lines. They don't often see forms like these with lines of intermediate lengths. The bimodal distribution of line length encourages the formation of distinctive categories. Making a distribution more bimodal than it normally is can aid learning, as shown by a study in which such a change promoted infants' discrimination of certain speech sounds (Maye, Weiss, \& Aslin, 2008).

Practice is important for learning. Active practice leads to more robust learning than passive exposure in populations ranging from infants to adults. For example, infants who observed an adult's action with a toy and who also
performed it were more likely to apply that action to a new toy than infants who only observed the action (Yang, Sidman, \& Bushnell, 2010). University students who generated "diamond" when asked to fill in the blank in "ruby: d___" later remembered the word diamond better than people who simply read "ruby: diamond" (Slamecka \& Graf, 1978).

Across a variety of tasks, performance tends to improve slowly at first. With additional practice, improvement becomes more rapid. This phenomenon is sometimes called learning to learn (Culler \& Girden, 1951). The rate of improvement often decreases as performance reaches its maximum. However, people often continue to get faster after accuracy has peaked. These increases in speed can continue for a surprisingly long time. University students, for example, have seen both man and map many, many times. One might expect performance on both words to have reached the same high level. However, university students reading those words take around 20 ms longer to begin pronouncing map than to begin pronouncing man (Balota et al., 2007), probably because they have seen man more often. These frequency effects persist after even another half century of reading experience, as documented by studies of 70 -year-olds (Balota, Cortese, Sergent-Marshall, Spieler, \& Yap, 2004).

A person who hasn't practiced a task very much must work hard to achieve a satisfactory outcome. This means that she may have difficulty performing another task at the same time. For example, a novice driver may find it hard to carry on a conversation or listen to the radio while she drives. With practice, driving becomes more automatic and the driver is better able to do other things at the same time, at least when road conditions are good. Similarly, spelling words is effortful for beginners. As children become more automatic with individual letters and words, they can devote more attention to other aspects of language (Logan, 1997). People like to feel that they can perform a task easily and well (Reber et al., 2004), and they are motivated to practice if they foresee the development of fluency.

Practice with a task or item, in addition to improving performance on that task or item, may also affect performance on others: transfer. Transfer is more likely to occur when tasks share many elements than when they share few. For example, understanding language has enough in common with producing it that hearing one sentence in the passive voice promotes later production of another passive sentence rather than an active sentence (Bock, Dell, Chang, \& Onishi, 2007). However, transfer can be surprisingly limited. US schools that pinned their hopes on the idea that the study of Latin would instill good habits of mind that would transfer to other content areas were disappointed to find weak evidence of transfer (Thorndike, 1923). Likewise, little evidence was found for the claim (Papert, 1980) that learning to program a computer would teach general problem-solving skills that would transfer to other types of problems (Fay \& Mayer, 1994; Lee \& Thompson, 1997). Indeed, people often fail to transfer what they have learned in one situation to a new one, even when the situations are more similar than programming a computer and planning the most efficient order in which to carry out a series of errands (Detterman, 1993).

As we will see in later chapters, approaches to spelling instruction that assume that children will transfer widely are also problematic.

The provision of ample input and ample opportunity for active practice are the foundations of the discovery view of learning, which is instantiated in the area of literacy instruction as the whole-language approach. Especially in difficult domains, however, pure, unguided, discovery is often insufficient. With computer programming, for example, approaches that include substantial direct instruction work better than approaches that stress unguided discovery (Fay \& Mayer, 1994; Lee \& Thompson, 1997). In general, research shows that people who are confronted with complex new material benefit from explicit guidance about what to do and how to do it (Alfieri, Brooks, Aldrich, \& Tenenbaum, 2011; Kirschner, Sweller, \& Clark, 2006; Mayer, 2004). Informal and ad hoc teaching may not suffice, and people may not transfer what they have learned about one item or problem to another. These conclusions apply to the learning of spelling, as to the learning of computer programming or chess. We turn now to some issues that arise in the design and conduct of direct instruction.

As mentioned earlier, children tend to learn and remember better when they generate answers themselves than when they passively receive the answers. However, children who don't know very much about a domain will sometimes generate wrong answers. According to the discovery view of learning, errors are good. They show that children are trying to make sense of what they are learning. Another hypothesis is that errors hurt learners by interfering with their memory for correct answers. In this view, teachers should create conditions that allow for errorless learning. Yet a third idea is that errors aren't always helpful or always harmful. Less important than whether or not learners make mistakes is what happens when they do. Supporting this third idea, one study showed that children's performance in a vocabulary learning task didn't differ as a function of whether they were required to answer when they were unsure or whether they were allowed to decline to answer (Metcalfe \& Kornell, 2007). What was important was what happened after children made mistakes.

Children who make a mistake are often told that they have erred and are provided with the correct answer. This information may come from a teacher, a parent, or a computer. In many experiments, although not always in real life, people receive corrective feedback every time they make a mistake. In the vocabulary learning study just mentioned, children scored higher on a final test when a computer tutor had provided them with the correct answers after they made errors in the practice phrase of the study than when no such feedback had been provided. In this study, as in many others, learners benefited from exposure to the correct answers (Bangert-Drowns, Kulik, Kulik, \& Morgan, 1991; Kluger \& DeNisi, 1996). Providing learners with correct answers after they have made mistakes is beneficial even if the learners feel sure that their original wrong answers were correct. Indeed, feedback is sometimes more successful with such errors than with errors that people aren't as confident about (Butterfield \& Metcalfe, 2006). This may happen because people are more
surprised to discover that they made an error in the former case. They devote more attention to the feedback and, if the situation permits, spend more time with it (Kulhavy \& Stock, 1989). An important role of feedback, therefore, is to help learners to fix their errors. Simply telling people that they made a mistake is less helpful than telling them the correct answer (Bangert-Drowns et al., 1991; Kluger \& DeNisi, 1996).

Corrective feedback may involve showing or telling people the correct answer, but it may also involve giving them enough hints so that they can generate it themselves. Under some conditions, this latter procedure leads to better memory for the correct answer than does standard corrective feedback (Finn \& Metcalfe, 2010).

So far, we have considered the feedback that learners receive after they have made a mistake. When learners respond correctly, it often doesn't help very much to tell them that they were correct and to provide them again with the correct answer (Bangert-Drowns et al., 1991; Kluger \& DeNisi, 1996). However, confirming that a correct answer was correct can benefit people who were unsure of their original response (Butler, Karpicke, \& Roediger, 2008; Kulhavy \& Stock, 1989). Feedback about correctness, in addition to strengthening correct answers, can reduce the overconfidence that we discussed in $\mathbb{\$ 3} \cdot 3$ (Butler et al., 2008). When children learn that they made some mistakes on a spelling test, for example, they are less likely to overestimate their performance on a later test.

Feedback is often explicit, making clear that the learner's original answer was wrong and making clear what the right answer is. For example, a teacher may put an $\boldsymbol{X}$ by a wrong answer on a spelling test and may write the correct spelling of the word. But feedback isn't always so direct. A 2 -year-old who says to her mother "Dolly no want bath" is unlikely to be told that her sentence was ungrammatical and that she should have said "Dolly doesn't want a bath" (R. Brown \& Hanlon, 1970). However, the child's mother may respond "Dolly doesn't want a bath but we'll give her one anyway," continuing the conversation and at the same time showing the correct grammar (Chouinard \& Clark, 2003; Hirsh-Pasek, Treiman, \& Schneiderman, 1984). To benefit from indirect feedback such as this, the child must understand that the adult's form is a better way of expressing the same meaning. She must compare the adult's form to her own, detecting the location of the difference. These things can be difficult. However, the difficulties can be lessened if feedback contains a clue as to the location of the error. For example, a teacher of a foreign language may repeat the erroneous part of a sentence that a learner produced, stressing the wrong word. Such an approach may be useful in situations in which explicit feedback would detract from the situation's goal-carrying on a conversation, in this case.

In many research studies, participants receive feedback immediately after they have produced a response. Computerized tutorials, too, usually provide immediate feedback. With human teachers, there is often some delay. For example, students may take a spelling test on Friday but may not receive
corrections from their teacher until Monday. In classroom situations, students who receive immediate feedback tend to do better on later tests than students who receive delayed feedback (Kulik \& Kulik, 1988). This may occur, in part, because children often pay more attention to immediate feedback. Delayed feedback can work better than immediate feedback, however, when steps are taken to ensure that people attend to it. This is probably because delayed feedback provides another opportunity to learn the material. Long-term retention is usually better after spaced learning trials than after massed ones, as we mentioned in $\sqrt{ } 3.4$, and delayed feedback can serve as an additional and well-spaced learning trial.

When giving feedback, should the teacher explain why the student's original wrong answer was wrong? For example, should a teacher explain why «giv> is an incorrect spelling of give? Explanations of why wrong answers are wrong don't always help learners (Sleeman, Kelly, Martinak, Ward, \& Moore, 1989). When learners aren't strongly committed to their errors-as when they produce wrong answers on the belief that it is better to produce something than nothing-it takes little convincing to get them to change their minds. In contrast, explaining why the correct answer is correct or getting learners to do this themselves is often helpful (Cain, 2007; Crowley \& Siegler, 1999; Siegler, 1995). Producing such explanations for other people, or even preparing to do so, can be particularly helpful (Bargh \& Schul, 1980; Rittle-Johnson, Saylor, \& Swygert, 2007). Thus, students who explain things to their peers often benefit, as do those who hear the explanations (Cohen, Kulik, \& Kulik, 1982). The explanations that people produce for others tend to be more explicit and detailed than the explanations that they produce for themselves, more sensitive to potential counterarguments that others may make. These considerations help to explain the value of explaining things to others. Having to explain things to other people also reduces the overconfidence that learners may otherwise show (Arkes, Christensen, Lai, \& Blumer, 1987). According to the discovery view of learning, children learn more when they invent their own explanations than when they obtain the explanations from others. However, that doesn't appear to be the case (Crowley \& Siegler, 1999).

A child may be told the correct answer and why it is correct after he has made a mistake. Alternatively, or in addition, explanations may be provided before a child tries to solve problems on his own. Explicit teaching of this sort is a hallmark of direct instruction, in spelling as in other domains. Research shows that learners don't always induce principles for themselves and that advance instruction that includes generic statements and explanations often helps them. Consider the classic study described by Judd (1908), in which boys were asked to throw darts at an underwater target. Half of the boys were taught in advance about the refraction of light, which causes the apparent location of the target to be deceptive, and half weren't taught. The target was submerged 1 foot during training, and the two groups did equally well here. There followed a task in which the target was brought up to 4 inches. The boys who had received the instruction about refraction did better on this task. Because they
understood the underlying principle, they could act more appropriately in the new situation.

Linguistic explanations of principles help, of course, only if learners understand them. The language that is used should be tailored to the learners' abilities, and the principles that are explained shouldn't be too distant from those the learners already know. That is, the new information should be within what Vygotsky (1978) called the zone of proximal development. To explain principles effectively, teachers should be able to see things from a child's perspective. As mentioned earlier, adults may have trouble appreciating a child's difficulties given their own expertise in a domain. Tutors who are just a little more advanced than their tutees may have an advantage in this regard.

The generic statements that teachers or parents provide, in spelling and in other domains, may have exceptions. How should exceptions be handled? One approach is to describe a rule, have learners practice it with examples for which it holds, and then explain that the rule doesn't hold in certain other cases. For example, students of French could be told, after practice with regularly inflected forms such as vous aimez 'you love' and vous sautez 'you jump', that vous dites 'you say' doesn't follow the pattern (1). Another approach is to describe the rule, have learners apply it to regular verbs, and then have them apply it to the stem for the verb for 'say'. After the students have produced vous disez, a regularization error, they are told that this verb is exceptional and are given its correct form. This second approach appears to lead to better memory for exceptional forms than the first approach, in line with the idea put forward earlier that the production of errors isn't in itself harmful (Tomasello \& Herron, 1988). The students who produced a regularization error and were then corrected may have done better because they paid more attention to the correct form, having been confident at first of the correctness of vous disez. In addition, these students may have adopted a more active approach to learning than the students who passively received the information about vous dites. Yet another consideration is that the teacher considered the regularization error to be intelligent and reasonable. The teacher may have conveyed this impression to the students, increasing their motivation to attend to and learn from the feedback.
(1) 'we...' 'you...'
nous aimons vous aimez 'love'
nous sautons vous sautez 'jump'
nous disons vous dites (!) 'say'
It is not enough to present learners with generic statements about principles and rules. Learners also need examples to understand how the generalizations apply in specific cases. In the previously described study by Judd (1908), boys were told about the refraction of light and also practiced throwing darts at submerged targets so that they could see the discrepancy between the apparent and actual location of the target. Telling the boys about the principle without having them practice with specific examples would have worked less
well, based on evidence that learners who receive rules but not examples may be able to state the rules but less able to apply them (Ellis, 1993).

Teachers can present students with generic statements and examples, or they can help students to induce appropriate generalizations from examples. Guided procedures of this latter sort work well in a variety of domains, in part because they encourage active engagement on the part of learners (Alfieri et al., 2011).

Given the central role of examples in teaching, the nature of the examples is important. Children tend to assume that adults, being knowledgeable and helpful, chose examples that demonstrate the full range of application of a rule or the full range of instances of a category. If provided with examples that fail to do this, children may form overly restricted generalizations (Bonawitz et al., 2011). Thus, teachers need to be sensitive to the examples that students use, whether they provide the examples to the students or help the students to come up with examples themselves. Teachers can treat different examples of a rule in the same way, using the same wording, and they can encourage students to do the same. Examples in which the conditions for a rule don't hold can be contrasted with examples in which the conditions hold in order to help students understand the conditions. Use of minimal pairs-items that vary in just the critical features and that are alike in other ways-can help learners determine what is important.

Often students are presented with information and are asked to study it on their own, either in school or at home. For example, students may be given a list of spelling words on Monday and told to study these words for a test on Friday. In many cases, students receive little guidance on how to study. Research shows this to be a mistake: When left to their own devices in studying, people don't learn as much as they could.

One reason that children don't always study effectively was mentioned earlier: They tend to overestimate how much they already know ( $\$ 3 \cdot 3$ ). Also, children don't always know which specific items they have mastered and which they haven't. It makes sense to spend more study time on items that aren't yet known than on items that are already mastered. However, children don't always do this (Lockl \& Schneider, 2004). Even university students, who have much experience studying, are far from perfect at judging what they do and don't know (Maki, 1998).

Effective methods of study require time and effort. However, children often satisfice, spending as little time and effort as possible in order to achieve what they consider to be a satisfactory short-term result. This tendency to think about the present rather than the future can cause children to use easy study techniques, not making the extra effort to use methods that are harder in the present but that yield better results in the future. For example, rehearsing the names of pictured objects is helpful in remembering the order in which the pictures were presented. Some 6- and 7 -year-olds use this method without prompting, but others take the easier approach of just looking at the pictures. The latter children remember the pictures better when they are taught the
rehearsal strategy and reminded to use it on every trial. However, the children may stop using the strategy when they are no longer reminded to do so (Keeney, Cannizzo, \& Flavell, 1967). Another effective method of learning, as mentioned earlier, is to explain the material to oneself or others. But that requires time and effort, and children may not do it when left to their own devices (Chi, de Leeuw, Chiu, \& LaVancher, 1994). These studies show that teaching students effective study techniques and prompting students to use these techniques can help their learning. As we will see in later chapters, this applies in spelling as in other areas.

### 3.6 Conclusions

General-purpose cognitive mechanisms play an important role in learning to produce writing, and we have discussed some of those mechanisms in this chapter. Children are limited in what they can perceive and remember. They use general patterns, including knowledge about how often things have occurred in the past, to learn new things and to reconstruct faded memories. They do this, in many cases, with little or no awareness of the patterns that they follow. Children learn a good deal from informal exposure to materials and to other people interacting with the materials. However, the learning of complex systems-especially those that are not a part of the human genetic endowment-can be improved by providing direct instruction. Effective instruction includes systematic teaching of the principles that underlie the system, practice with well-chosen examples, and correction of students' errors. It includes not only specific content but also guidance on how to learn efficiently and well.

We refer to the material covered in this chapter in the chapters in the central section of this book, chapters 5 through 15 , which review the research on specific aspects of orthographic learning. In each of those chapters, we consider how the principles of learning and teaching that we discussed in this chapter play out in that specific area. Before considering the research on how children learn to spell, however, it is important to discuss theories about orthographic knowledge and its development. We present these theories in chapter 4.

## CHAPTER 4 <br> Theories

A NUMBER OF THEORIES have been developed in an attempt to explain how children learn to produce writing. We discuss some of the major theories in this chapter. We seek to familiarize the reader with the important characteristics of each theory and with some of its implications for teaching. Our aim is to provide a background for chapters 5 through 12, each of which reviews studies of children's learning of a specific aspect of orthography and discusses the research in light of relevant theories.

The main goal of a theory of orthographic knowledge and its development is to explain data on psychological processing and performance. A theory should be consistent with what is known about human learning and writing systems, as well with how writing systems are made available to learners. A theory should explain, with a unified framework, how children learn aspects of writing ranging from the shapes of the characters to spelling to punctuation. It should explain why some aspects are relatively easy to learn and why other aspects are more difficult, and it should explain why learners of different writing systems sometimes show different patterns of performance. For example, why do learners of Spanish tend to spell vowels better than consonants (Manrique \& Signorini, 1994, 1998), whereas US learners of English tend to show the opposite pattern (Treiman, 1993)? A theory should explain, too, why other patterns of performance are similar across writing systems and cultures. Spelling is different enough from reading that, even if we had a theory of how children learn to read words, we would also need a theory of how they write them. At the same time, a theory of spelling should link to what we know about reading.

A number of theories have been developed in an attempt to meet the desiderata just described. We begin the chapter by discussing the traditional idea that spelling involves mostly the rote memorization of arbitrary forms and sequences. We next discuss the dual-route theory, which postulates that people
use a set of spelling－to－sound rules as well as stored knowledge of whole－word spellings．In the sections that follow，we deal in turn with constructivist theory and phase theory．We then discuss connectionist models and IMP，the theory that we advocate．In the final section of the chapter，we consider the types of evidence that can help to distinguish among the theories．This discussion sets the stage for chapters 5 through 12 ，each of which reviews evidence on a spe－ cific aspect of orthographic learning．

## 4．1 Rote Memorization

Learning to spell，particularly in certain writing systems，has often been seen as a process of rote memorization．This view is in some ways not on par with the other theories discussed in this chapter；it is more a traditional idea than a serious present－day scientific theory．Still，the idea that spelling relies on rote memorization has been so influential for instruction that it is worth some consideration．

According to the rote memorization view，children memorize the shapes of letters and the spellings of words，learning the spelling of a word in much the same way that they would learn an arbitrary list of items in an experi－ mental psychology laboratory（Jensen，1962）．For example，English－speaking children learn to associate the word／spau／with the letter sequence＜s＞，＜p＞，〈i〉，〈r〉，〈e〉 and the word／kwail／with the sequence 〈c＞，〈h〉，〈o〉，〈i〉，〈r〉．They could have learned just as easily that／spau／goes with 〈p»，«q＞，«n»，«u〉，«w〉． The development of spelling skill，according to the rote memorization view， involves increases in the number of spellings that are stored in memory and increases in the accuracy and speed with which those memories are retrieved． Experienced spellers know more words than beginners，but both groups learn and remember spellings in the same way．

The factors that affect spelling，according to the rote memorization view， are the same factors that affect the learning of other arbitrary sequences． Experimental psychologists in the verbal learning tradition，who focused on the learning of arbitrary sequences and associations，found that the first few items of a sequence tend to be remembered well：the primacy effect．The last few items also tend to be remembered well，the recency effect．Correspondingly， the rote memorization view predicts that the first and last letters of a word should be easier to spell than the middle letters．The relationship between the letter string and the linguistic form for which it stands shouldn＇t influence performance．Thus，letters that clearly correspond to a word＇s sounds，such as the «s＞and＜p＞of spire，shouldn＇t be learned more easily or recalled any better than letters that don＇t correspond so clearly to the sounds，such as the＜o＞and the «i＞of choir．If a girl has seen spire and choir the same number of times， she should spell the second word as easily as the first．She shouldn＇t treat as a chunk letters such as the «ch＞of choir，which can be considered to represent a single sound．

The rote memorization view of spelling assumes that the spellings of words are largely arbitrary, at least in certain writing systems, and that children are well equipped to learn arbitrary sequences, given sufficient practice. The English writing system is thought to have such unpredictable correspondences between spellings and linguistic units that its users do best to rely on rote memorization of whole words, ignoring phonology (Sloboda, 1980). Although English has some regular words, such as spire, the existence of many exception (irregular) words such as choir means that it isn't worthwhile for children to try to use rules that relate spellings to sounds or for teachers to try to teach such rules. It has also been suggested that rote memorization "is all that could be used for languages with scripts like Chinese, in which, essentially, each word has its own unique character" (Barry, 1994, p. 31).

Learning to spell, according to the rote memorization view, requires direct instruction. Children who are learning an alphabetic writing system should begin by memorizing the letter names in their conventional order and by learning the letters' shapes. They should memorize the spellings of words through such activities as copying them over and over or visualizing them in their minds. Children who are taught by such approaches are sometimes asked to memorize a list of words each week. The words in a list may not share spelling patterns or sound patterns but may be chosen, instead, based on frequency of use or similarity in meaning.

### 4.2 Dual-Route Theory

Dual-route theory (Barry, 1994; Kreiner, 1992; Kreiner \& Gough, 1990; Martin \& Barry, 2012) focuses on the moment-by-moment processes that occur as people spell individual words. The central idea is that people have two different methods at their disposal: a lexical route, which is based on whole-word memory, and a nonlexical route, which is based on rules. Dual-route theories of spelling, which are closely related to the influential dual-route theories of reading (Coltheart, Rastle, Perry, Langdon, Ziegler, 2001), have been applied primarily to alphabetic writing systems, whose basic characters stand for phonemes ( $\$ 2.2 .2$.3). Dual-route theory emerged from the information processing tradition in cognitive psychology, which attempts to describe the steps that occur as the mind takes in information, performs operations on it, and produces responses. Dual-route theories were also influenced by the generative tradition in linguistics, which sees language as governed by rules that allow its users to produce and understand new items.

To understand how the lexical and nonlexical routes are thought to operate, we begin by describing several memory stores that play important roles in dual-route theories of spelling and reading. The orthographic lexicon contains information about words' spellings. It is similar to the memory store assumed by advocates of the rote memorization view of spelling in that the frequency with which a written form has been encountered is a major determinant of
storage. Words that have been read or written often tend to have complete and accurate entries in the orthographic lexicon. A word that has been encountered less often may have no entry at all, or its entry may be erroneous or incomplete. Spellings such as the English «swift» and «sword», which dual-route theorists characterize respectively as regular and exceptional, are stored equally well in the orthographic lexicon if they have been seen and practiced equally often.

Some investigators (Morton, 1980) have suggested that people have one orthographic lexicon for spelling and another orthographic lexicon for reading. According to this two-lexicon view, a boy who can read necessary but not spell it has the word in his reading lexicon but not in his spelling lexicon. However, as we discussed in chapters 1 and 2, one can explain why spelling is harder than reading without postulating separate memory stores for the two tasks. Most dual-route theorists thus maintain that people use a single orthographic lexicon for both reading and spelling.

Another memory store that plays a role in spelling, according to the dual-route view, is the phonological lexicon. This contains information about words' phonological forms. Children possess a phonological lexicon before they learn to read and write. As they learn to do so, entries in the phonological lexicon link with those in the orthographic lexicon. Yet another memory store that is involved in spelling is the graphemic buffer. This is a temporary memory store that maintains a letter string while it is being written or typed.

The lexical route begins when the entry for a word in the phonological lexicon becomes active. This can happen upon hearing the word, thinking of the word, or seeing a picture. This in turn activates an entry for the word in the orthographic lexicon, if an entry exists. This activation may involve a direct link between the phonological form and the orthographic form or it may be indirect, with one link from the phonological form to the meaning and another from the meaning to the orthographic form. In either case, the spelling is then read out of the orthographic lexicon. The lexical route will work quickly and well if an item has entries in both the phonological and the orthographic lexicon and if the two are correctly linked. The lexical procedure will fail with nonwords, such as /sorf/ for English, which lack entries in the phonological and orthographic lexica. The lexical route may also fail for uncommon words, since the entry in the orthographic lexicon may be missing or incomplete.

According to the dual-route view, spellers have a nonlexical route as well as a lexical one. In an alphabetic writing system, the nonlexical route involves segmenting a phonological form into phonemes. A spelling is generated by means of stored rules that link phonemes to phonograms ( $(\mathbb{2} .2 .2 .2)$, which are letters or groups of letters that correspond to individual phonemes. Psycholinguists often refer to these as graphemes. However, because many other writers use that term only to refer to the smallest units of writing, such as single letters but not groups of letters, we will avoid the term here. Spellers of English, for example, have a rule that links the phoneme $/ \mathrm{S} /$ to the phonogram «sh . If they use the nonlexical route to spell chef/ $\int \varepsilon f /$, they will regularize it, using initial <sh rather than «ch>. A phonogram may be a single letter, as with «s> for /s/; a
digraph，as with «sh〉 for $/ \mathrm{S} /$ ；a trigraph（three－letter phonogram），as with «eau＞ for French／o／；or a split digraph，as with «a〉 followed by final «e» for English ／e／（as in «came»）．Dual－route researchers assume that people treat multi－letter phonograms as unanalyzable units，on a par with single letters．Thus，children who are learning English memorize that «sh＞stands for $/ \mathbb{S} /$ in the same way that they memorize that «s＞stands for／s／．Dual－route researchers also often assume that the nonlexical route works in a serial manner．That is，it assigns a spelling to the first phoneme of a word，then to the second，and so on through－ out the word（Simon \＆Simon，1973）．

The nonlexical route is the only method that can be used to spell nonwords， and it is also the only method that can be used to spell words whose spellings have not previously been encountered．For other sorts of words，a speller could use both routes．Dual－route theorists have considered different ways in which people may do this（Barry，1994）．For example，both routes may operate independently and simultaneously and people may produce the spelling that is generated most quickly．Alternatively，the two routes may cooperate in some way．

Because dual－route theorists haven＇t laid out complete lists of the sound－to－spelling rules for specific writing systems，it is difficult to make detailed statements about the nature of the nonlexical route．However，some versions of dual－route theory assume that each phoneme is associated with a single phonogram．For example，／a／is associated only with «a＞in Italian．The nonlexical route thus produces correct spellings for the many Italian words in which／a／is spelled with «a＞but incorrect spellings for the few words whose phonological forms begin with／a／but whose spellings begin with «ha»，such as hanno＇they have＇．In other dual－route theories，a phoneme may have sev－ eral spelling options，each with an associated probability（Barry \＆Seymour， 1988；Kreiner，1992）．In such a view，English／k／has a certain probability of being spelled with＜c＞，a certain probability of being spelled with 〈k〉，and a certain probability of being spelled with «ck»．The probabilities don＇t depend on the position of $/ \mathrm{k} /$ within the word，the preceding or following phonemes， or the morphological structure of the word（the smaller units of meaning，or morphemes，that it contains）．The correspondences are unconditioned，in that all $/ \mathrm{k} /$ phonemes have the same chance of being spelled with $\langle\mathrm{c}\rangle$ ，regard－ less of what sounds come before or after them．Yet a third idea is that some rules involve units that are larger than single phonemes．A popular idea is that these involve rimes，such as／æg／in／bæg／bag．Some dual－route models of reading include links at the rime level in addition to links at the phoneme level（Patterson \＆Morton，1985），and such links may also operate in spelling （Goswami，1988；Martin \＆Barry，2012）．Thus，people may divide／bæg／into ／b／and／æg／when using the nonlexical route．They spell it by rules that link ／b／to «b＞and／æg／to＜ag＞．

Dual－route theorists describe writing systems as differing on a continuum of orthographic depth．As we mentioned in chapter 2，Chomsky and Halle （1968）introduced the term deep to refer to spellings that reflect any property of language other than the sounds that pass between speaker and hearer．For
example, in the word health $/ \mathrm{h} \varepsilon 1 \theta /$, the unusual spelling of $/ \varepsilon /$ (<ea>, which usually spells /i/), can be explained as a deep spelling because it shows the morphological connection between this word and heal/hil/. Deep spellings often introduce inconsistency into sound-to-phonogram mappings: Words like health lead to more uncertainty as to how $/ \varepsilon /$ should be spelled. Dual-route theorists have generalized this concept of deep spelling to refer to any kind of complication in alphabetic spelling, using the term rather differently than Chomsky and Halle (1968). For dual-route theorists, a deep writing system contains "orthographic inconsistencies and complexities, including multi-letter graphemes, context dependent rules, irregularities, and morphological effects" (Seymour, Aro, \& Erskine, 2003, p. 146). Dual-route theorists consider luck /lək/ to be evidence of deep orthography in English because /k/ is spelled with two letters and also because that consonant is spelled differently after two-letter vowel spellings as in look-complexities that are not motivated by any property of the English language itself. Whereas English is considered to be a deep alphabetic writing system, Finnish and Italian are considered to be shallow.

The depth of a writing system is important, according to dual-route theorists, because it affects users' relative reliance on the lexical and nonlexical routes. Indeed, dual-route theorists have questioned whether a lexical route is needed at all for shallow writing systems. A nonlexical route with simple sound-to-spelling rules could be used for all words and would almost always yield correct spellings. Some dual-route theorists have suggested that users of shallow writing systems don't use a lexical route, at least for reading (Turvey, Feldman, \& Lukatela, 1984). Other researchers have suggested that a lexical route operates even in shallow orthographies (Barry \& de Bastiani, 1997). Despite these disagreements, dual-route theories agree that the lexical route is less important for shallow writing systems than for deep ones. Versions of the dual-route theory that have been put forward for English thus give priority to the lexical route over the nonlexical route (Kreiner, 1992).

The success of the lexical route is thought to depend on the precision and completeness of the entries in the orthographic lexicon. This, dual-route theorists suggest, depends in large part on how often a word has been encountered during reading. Researchers have thus looked for a frequency effect-better performance on words that occur often in books, newspapers, and so on than on words that appear less often. They have also looked for a lexicality effect-better performance on words than on nonwords, which have a frequency of zero. Frequency and lexicality effects are seen as diagnostic of the existence and importance of a nonlexical route.

The success of the nonlexical route depends on the degree to which the word conforms to the sound-to-spelling translation rules that this route embodies. Although there are different ideas about the nature of these rules, as we have discussed, most studies within the dual-route framework have placed words into categories based on the assumption that rules link each phoneme to a single phonogram, regardless of the context in which the phoneme occurs.

A word is classified as regular if each phoneme is spelled with the phonogram that most commonly represents that phoneme. If not, the word is exceptional. Seeing regularity as a dichotomy, many researchers in the dual-route tradition have compared people's performance on regular words and exception words that are matched or statistically controlled for other variables known to affect spelling, such as length and frequency. Researchers have assumed that, because only regular words benefit from use of the nonlexical route, people should spell regular words more accurately, more quickly, or both, than exception words. This regularity effect is seen as diagnostic of the existence and importance of a nonlexical route.

Dual-route researchers predict that regular words differ from exception words not only in overall level of spelling performance but also in the degree to which performance is influenced by the word's frequency of use (Delattre, Bonin, \& Barry, 2006). Frequency has a relatively large effect on the spelling of exception words because the spellings of these words must be looked up in the orthographic lexicon, which is highly sensitive to frequency. Frequency has a smaller effect on regular words because the spellings of these words are often constructed using the nonlexical route rather than looked up.

Although much work within the dual-route framework has been carried out with skilled spellers, this framework has also guided studies of children. According to developmental versions of dual-route theory, young children rely heavily or even exclusively on the nonlexical route (Alegria \& Mousty, 1996; Sprenger-Charolles, Siegel, \& Bonnet, 1998). Use of the lexical route is thought to increase with increases in spelling skill. Given the developmental priority of the nonlexical route, and given that the nonlexical route yields correct spellings in shallow writing systems, shallow writing systems should be easier to learn than deep ones. To use the nonlexical route, researchers in the dual-route tradition suggest, children must possess a degree of phonemic analysis skill. They must also know the basic correspondences between sounds and letters, sometimes referred to as alphabet knowledge. Researchers in the dual-route tradition have devoted less attention to other skills that may be important for spelling, such as how children learn that writing represents language-that it is glottographic ( $\$ 2.2 .2$ )—and how they learn about the shapes of letters (the topic of chapter 8).

According to developmental versions of the dual-route view, the lexical route doesn't change qualitatively from childhood to adulthood. The changes that occur are quantitative: Children store more spellings in their orthographic lexicon as they gain experience, and the stored spellings become more accurate and easier to retrieve. There may be qualitative changes in the nonlexical route, however. One idea is that younger children use rules that associate a single phonogram with each phoneme (Marsh, Friedman, Welch, \& Desberg, 1980). Older children spellers have more complex rules, ones that allow for several spelling choices for each phoneme. Another idea, which is consistent with some research findings (Goswami, 1988), is that young children rely heavily on rules that involve whole rimes. Older children use rules that are based on
smaller units. Thus, a young child might memorize <ag> as a spelling for /æg/. An older child might generate this spelling on the basis of rules linking /æ/ to «a> and /g/ to 〈g>.

The idea that simple rules that relate phonemes and phonograms play an important role in spelling is compatible with phonics instruction. In this approach, as described in $\$ 1.3 .2$, children are taught about the letters of the alphabet and the rules by which they link to sounds. Children are encouraged to use these rules to spell regular words such as maid and home, and they are encouraged to memorize the spellings of exception words such as said and come. The idea that use of the nonlexical route requires segmentation of spoken words into phonemes has also been taken to support the teaching of phonemic analysis to children.

### 4.3 Constructivism

Whereas dual-route theory has been applied both to adults and children, constructivist theory focuses on children ( $(\mathbb{1} .3 .1)$. This theory was proposed by Ferreiro and her colleagues, and it is based on the work of Piaget (Ferreiro, 1990; Ferreiro \& Teberosky, 1982). Ferreiro, following Piaget, emphasized the hypotheses that children develop as they try to understand the world around them-here as they try to understand the nature of writing. According to Ferreiro's theory, children pass through stages of literacy development that differ qualitatively from one another. Each stage is characterized by a particular hypothesis about how writing works, and children use this hypothesis both when spelling words and reading them. Children take in information about writing and interpret it in light of the hypotheses they hold at the time, or in Piaget's terms assimilate the new information into their existing schemas. Children's schemas are normally rather stable. However, if children receive a substantial amount of evidence that can't be assimilated into their existing hypotheses, they will change their hypotheses and enter into a new stage of development. Piaget viewed the stages of cognitive development as universal, applying to children in all societies. Similarly, Ferreiro expected that the stages of literacy development that she found in her work with Spanish-speaking children would apply more broadly. Indeed, Ferreiro's ideas have been extended to learners of other alphabetic writing systems, including Portuguese (Alves Martins \& Silva, 2001), Italian (Pontecorvo, 1985), French (Besse, 1993), and English (Kamii, Long, Manning, \& Manning, 1990).

Ferreiro and her followers described three stages of development during the course of which children adopt different hypotheses about written language. During the presyllabic stage, children may not understand that writing represents language. They may think, instead, that it represents people and objects directly. For example, Ferreiro (1986) described a Spanish-speaking $2^{1 ⁄ 2}$-year-old for whom $\langle\mathrm{P}\rangle$ appeared to symbolize his own father rather than the word papa. Fathers other than his own, the child appeared to think,
couldn’t be associated with 〈 P$\rangle$. Children in the presyllabic stage may believe that writing represents its object by virtue of physical resemblance: that it is iconic ( $\$ 2.3 .1$ ). For example, a 4 -year-old who had produced a wavy line when asked to write pato 'duck' made a longer line for oso 'bear', explaining that a bear is bigger than a duck (Ferreiro \& Teberosky, 1982). Another child said that his father's name should be longer than his name because father was older and bigger. In these and other examples cited by Ferreiro and Teberosky, children sought correspondences between the number of marks, size of marks, or length of the written production and the number, size, or age of the objects for which they stood. According to constructivist theories, children postulate iconicity even though the writing that they see provides little or no evidence for it. For example, the spellings of words that represent large objects don't generally contain more letters than the spellings of words that represent small objects. Ferreiro and Teberosky didn't observe children using letters with particular shapes or colors to stand for objects with similar shapes or colors, but other researchers have suggested that children sometimes do this (Levin \& Tolchinsky Landsmann, 1989).

During the presyllabic stage, according to Ferreiro, children believe that a text must contain at least several letters: the minimum quantity hypothesis. The minimum is thought to be fixed for a given child, being typically either three or four letters. It isn't closely tied to the lengths of the texts that the child has seen. Thus, even children who have been exposed to Spanish, which contains a number of short words such as $t u$ 'your' and $l e$ 'him', don't produce short spelling themselves. Children in the presyllabic stage also hypothesize that the letters in a string should be different from each other. We call this the within-word variation hypothesis. Thus, children may produce a spelling such as «BLN» but not one such as «BBB». Another hypothesis that children are thought to hold during the presyllabic stage is that words that convey different meanings should look different. We call this the between-word variation hypothesis. For example, a child who spelled cat as 〈MPD> wouldn't spell dog as <MPD> immediately thereafter. The child might instead write «DMP> or «PMD>, rearranging the letters she knows into a different sequence so as to convey a different meaning.

Children's early concepts of writing are thought to encompass its universal characteristics but not its local variations. Thus, the writing of presyllabic stage children may include features that are common to all writing systems, such as being composed of units that are placed along a line. As children develop, they begin to include features that are specific to the writing system to which they are exposed, such as left-to-right directionality in the case of English or Spanish (Tolchinsky, 2003).

In Ferreiro's view, children move from the presyllabic stage into the syllabic stage. In the syllabic stage, children take each unit of writing to represent a syllable, a unit of spoken language that is fairly accessible to them. Children often produce spellings that that have one symbol for each syllable. Thus, a young Spanish speaker might write the two-syllable word sapo 'frog' with two
symbols. These may be «A〉 and «O», or they may be forms that aren't conventional letters. Writing one symbol for each syllable of a short word causes spellers to deviate from the principle of minimum quantity, however. According to Ferreiro, this principle may be temporarily suppressed when children enter the syllabic stage. Alternatively, children may attempt to solve the conflict between the syllabic hypothesis and the minimum quantity hypothesis by using more letters than syllables to spell short words but attributing no sound value to the extra letters.

Children who are learning an alphabetic writing system may remain in the syllabic stage for some time, even though most words they see have more letters than syllables. Eventually, unable to assimilate such experiences into their schemas, children abandon the syllabic hypothesis and adopt the hypothesis that letters correspond to phonemes. Children are now in the final stage of development, the alphabetic stage. Constructivist theorists have paid relatively little attention to this stage. For example, they have not said very much about how children learn that a phoneme may have more than one possible spelling or how children choose among the options. Even in Spanish, the language that has featured in much of the constructivist research, some phonemes correspond to more than one phonogram.

The goal of literacy instruction, according to Ferreiro's theory, is to encourage children to move from one stage to the next. Because children will understand an idea better if they develop it themselves than if it someone else presents it to them, children should be put in situations that lead them to discover new ideas about writing. For example, a teacher may assess which stage a child is in and then show the child spellings that were produced by a child in the immediately following stage. The child may be asked to compare her spelling of a word with the other child's spelling, to choose which spelling is better, and to justify the choice. The teacher doesn't tell the child which spelling is better, and indeed neither spelling may be correct. The idea is to promote discovery: to help the child understand that her hypotheses about spelling are incomplete and that she should adopt new ones ( $\$ 1.3 .1$ ). Constructivist researchers have suggested that such teaching methods improve the quality of children's spellings (Alves Martins \& Silva, 2006), and teachers in such countries as Mexico and Brazil are strongly influenced by the constructivist approach.

### 4.4 Phase Theory

Phase theory, like constructivist theory, focuses on the development of literacy in alphabetic writing systems. Originally proposed on the basis of research with English-speaking children, it has since been applied to learners of other alphabetic writing systems such as Portuguese (Cardoso-Martins, Corrêa, Lemos, \& Napoleão, 2006). Our description of phase theory is largely based on the work of Ehri $(1997,2005)$. The central assumption of phase theory is that different types of knowledge and different processes predominate at different points in
development．Ehri rejected the strict stage theories that had been put forward by some earlier researchers，suggesting that，although the operative principles of each phase differ in many ways from those of previous phases，the phases aren＇t completely rigid．However，Ehri＇s phase theory is similar to several ear－ lier stage theories（Frith，1985；Gentry，1982；Henderson \＆Templeton，1986）in its stress on the importance of phonological knowledge．We incorporate ideas from these stage theories in the discussion that follows．

During an initial phase of development，children write things such as ＜SSHIDCA〉 for＂welcome home＂（Bissex，1980）that reflect＂random string－ ing together of letters of the alphabet＂（Gentry，1982，p．193）．The US boy who wrote $\langle$ SSHIDCA $\rangle$ didn＇t know about the conventional relationships between phonemes and letters．He may not have even known that writing is glotto－ graphic．The boy also didn＇t know about certain graphotactic constraints of English，such as the fact that «SS〉 can’t occur at the beginnings of words．This initial phase of development is often called the prealphabetic phase．This term was chosen not to indicate that children don＇t yet write with letters of the alpha－ bet but to indicate that they don＇t yet comprehend the alphabetic principle：the fact that letters represent phonemes．These children＇s＂attempts to discover correspondences between the writing system and the language occur at the level of meaning＂（Ehri \＆T．Roberts，2006，p．117）．Searching for similarities between the visual form of a word and the visual form of the objects that it sig－ nifies，or visual iconicity $(\sqrt{2} .3 .1)$ ，a child may relate the shape of the rightmost letter of 〈dog＞to the tail of a dog．Most of the descriptions of prealphabetic phase children that are provided by phase theorists，however，focus on what the children don＇t do－represent language at the level of phonemes－rather than on what they do．

As children begin to understand that letters symbolize phonemes，and as they begin to analyze speech at this level，they are said to enter the partial alpha－ betic phase．During this period，which occurs around the age of 6 years in many cultures，children spell some of the sounds in words but not others．Children in the partial alphabetic phase may be familiar with the conventional names of letters，and they may use their knowledge of letter names as a basis for spell－ ing．For example，children may write far as 〈FR＞，mess as 〈MS ，and hay as 〈HA〉． Indeed，Gentry（1982，p．194）claimed that children use a letter name strat－ egy whenever the opportunity arises：＂Where possible the speller represents words，sounds，or syllables with letters that match their letter names．．．instead of representing the vowel and consonant sounds separately．＂

During the next phase，the full alphabetic phase，spellers represent words＇ phonological forms completely or almost completely．The errors that children make during this period，such as «kar» for＜car»，are phonologically plausible in that children represent each phoneme in a word with a phonogram that may be used to spell it in their writing system．However，children may not use the correct phonogram for the word in question．Although full alphabetic phase spellers know a good deal about how letters represent sounds，they know rela－ tively little about graphotactic patterns．For example，a full alphabetic phase
speller might spell the $/ \mathrm{k} /$ of car as «ck», a spelling that is phonologically but not graphotactically acceptable in English. Full alphabetic phase spellers are also thought to know little or nothing about the role of morphology in spelling. For example, a child in the full alphabetic phase might spell fleas as <fleeze>, not knowing that final $/ \mathrm{z} /$ should be spelled as $\langle\mathrm{s}\rangle$ when it is a plural morpheme. At this point, it has been suggested, children choose letters "strictly on the basis of sound, without regard for acceptable English letter sequence or other conventions of English orthography" (Gentry, 1982, p. 195).

The fourth period of spelling development is the consolidated alphabetic phase. Spellers now treat common letter sequences such as <ight», <ing>, and <at> as chunks ( $\$ 3.1$ ). They begin to follow graphotactic conventions in their writing, no longer producing spellings like <ckar> for «car> that deviate from these conventions. English-speaking children also begin to spell some morphemes consistently, even when their pronunciations differ. For example, children write «ed» for the English past tense marker regardless of whether it is pronounced $/ \mathrm{t} /$, /d/, or /əd/. They use <i> in the second syllable of definition based on their knowledge of define. According to some investigators, children use morphology when spelling inflected forms such as jumped before they use morphology for derived forms such as cloudy or definition (Henderson \& Templeton, 1986). Children also learn about the spelling changes that may occur when syllables combine. For example, they learn that the <p> of <hop> must be doubled in «hopping».

Educators who are influenced by phase theory and its predecessor stage theories have suggested that teachers should identify the phase of spelling development that a child is currently in and should tailor instruction accordingly. They have suggested methods of identifying a child's current phase and have recommended instructional activities that can help the child to move from that phase to the next, such as sorting words into categories based on the elements that they contain (Ehri \& McCormick, 1998; Henderson \& Templeton, 1986; Invernizzi, Abouzeid, \& Gill, 1994).

### 4.5 Connectionist Theories

Connectionist theories attempt to explain cognition in terms of networks of simple units and learning in terms of changes to these networks. They differ from the information processing theories that underlie dual-route models in a number of respects, including their emphases on parallel rather than serial processing and on statistical learning rather than the learning of all-or-none patterns. According to advocates of connectionist theories, these and other characteristics of the theories make them plausible in terms of what is known about the brain. Connectionist theories are implemented as computer programs, meaning that they are at a different and more mechanistic level than the other theories discussed in this chapter. The connectionist models of spelling that we discuss in this section are single-route models, in the sense that they
assume that a single network can be trained to produce correct spellings of all types of words, including regular words, exception words, and nonwords. This contrasts with the dual-route view $(\$ 4.2)$, which sees the nonlexical route as important for the spelling of nonwords and regular words and the lexical route as important for exception words.

A connectionist model includes several types of units, and each unit may be active or not active at a particular point in a time. Input units in a model of spelling code information about phonemes, and output units code letters. Each spoken word is represented as a pattern of activation across a large number of input units. Similarly, each spoken word is represented as a pattern of activation across a large number of output units. Items that are similar to one another, such as words with similar pronunciations, activate many of the same units. The input units in the models discussed here don't connect directly to the output units. The input units link instead to a set of hidden units, which in turn link to the output units.

In a typical connectionist learning model, the weights between the units start out with small, randomly chosen values. This means that, when the model is presented with an input, it rarely produces the correct output. Learning involves modifying the connections between the units in response to feedback. On each training trial, the model is presented with an input in the form of a pattern of activation across the input units that represents the pronunciation of a word. The model then computes an output. It compares its output to the correct output, which is provided to it on each learning trial in a way that is meant to be analogous to an adult telling the child the correct spelling of a word or to the child finding out the correct spelling in some other way. The weights on the connections are adjusted so as to minimize the difference between the output that is generated by the current state of the network and the correct output. Learning is thus a property not of single connections but of the whole system. A fully trained model is thought to capture the statistics of the input to which it has been exposed; the model is in some sense an optimal learner (G. D. A. Brown, 1998).

A connectionist model tends to learn most rapidly when similar inputs are mapped to similar outputs. The connections that are used in one case thus overlap with those that are needed for others, permitting cooperation. The model learns more slowly when a specific input maps to one output under certain conditions but another output under other conditions. In such cases, the two sets of mappings may compete with each other: interference. After training, connectionist models respond appropriately to many novel inputs. They tend to perform better on new patterns that are similar to stored patterns than on new patterns that are quite different. In some cases, though, a model may treat a new input similarly to an old one in situations where this isn't appropriate.

Whereas dual-route theorists classify words as having either regular or irregular spellings, a dichotomy, connectionists see words as differing along a continuum that they have referred to as consistency. For example, /sop/ activates the spelling «soap» but, being similar to /hop/ hope, /aop/ rope, and so
on, it also activates «sope». The consistency of «soap» is thus said to be relatively low. The word pill is said to be high in consistency because the words that are similar to it, including mill, hill, and pin, are spelled similarly. Researchers in the connectionist tradition (Glover \& Brown, 1994) have looked for consistency effects: better performance by people and computational models on more consistent words than on less consistent words. These researchers have normally defined consistency at the level of rimes, labeling a word as consistent for spelling if other words with the same rime pronunciation have the same rime spelling.

The single-route connectionist models that have been implemented for spelling are small in scale and restricted to English. G. D. A. Brown and Loosemore (1994) trained their model of English spelling on just 225 words, and Bullinaria (1997) used a larger set of words, but only monosyllables. These models have had some successes. For example, Brown and Loosemore's model learned to spell inconsistent words such as soap more slowly than consistent words such as pill, behaving like people in this regard. The models have a number of limitations, however. They treat spellings as representing language, and they treat spoken words as sequences of phonemes. They don't have to learn these things, as children must. Knowledge of letter shapes is also built into the models. The models needn’t learn to discriminate between $\langle\mathrm{n} »$ and $\langle\mathrm{h}\rangle$ or to deal with different fonts or letter cases, as children must. The model of Olson and Caramazza (1994) codes phonograms such as the <i_e> of bite and the <gh> of ghost as units, whereas children must learn about such groups. A model always receives the correct answer after it spells a word; children often don't. The model of Olson and Caramazza receives feedback not only about the spelling of a word but also about which letters correspond to which sounds. Children don't usually get this latter type of feedback.

Connectionist theory grew out of artificial intelligence rather than out of an interest in pedagogy, and its implications for instruction haven't been explored in much depth. However, such theories invite the inference that children will pick up the statistical patterns of their writing system implicitly if they practice with a representative sample of words and if they see the correct spelling of a word after they misspell it. If a model can learn to spell without explicit instruction about the writing system, children may be able to learn in this way, too.

### 4.6 IMP

IMP, the Integration of Multiple Patterns, is the theory that we propose and defend in this book. As we discuss in later chapters, we believe that it provides the best account of the data on children's acquisition of writing. IMP sees children as learning both about the spellings of specific words and about general patterns, namely, those that apply across words and across the symbols of a script. Children learn probabilistic patterns as well as deterministic patterns
( $\$ 3.1$ ). Moreover, spellers use multiple patterns even on the same word. Use of multiple patterns makes spellings more motivated and less arbitrary, reducing the need to rely on rote memory. Children tend to do well when several patterns converge on the correct answer. They have more difficulty when this isn't the case.

The patterns that children learn in learning about writing fall into two main categories. One class of patterns relates to the outer form of writing. For example, a child who has learned about the design characteristics of the Latin letters knows that «b> is a plausible member of the set but that $\bar{\omega}$ isn't. A child who has learned about the sequences of symbols that occur in written English knows that «cat» is a possible word but that «TTT〉 and «ckAt» aren’t. Similarly, the child knows that <lin, gef» looks more like a stretch of print than «lin,g ef». Knowledge about graphic patterns helps to limit the set of possibilities that children will consider. For example, a child who remembers the first and last letters of <mom> but who is unsure of the middle letter won't consider $<\mathrm{mmm}$ > as a possibility if he knows that sequences of three identical letters don't occur in English. The formal patterns mentioned so far pertain to the visual appearance of writing, its outer form. Other formal patterns that are involved in learning about a writing system relate to the sound shapes of spoken words. For example, children learn that letter names follow certain phonotactic patterns, that is, patterns involving the order and arrangement of phonemes.

A second class of patterns involves links between graphic forms and language. Whereas knowledge about the outer form of English tells a child that <cat» is a possible word and that <mom> is another, knowledge about the linguistic units that the letters represent tells him that «cat» must represent /kæt/ and «mom» /mam/. Knowledge about letters’ linguistic functions helps to motivate the «c> of <cat» by specifying that it represents the $/ \mathrm{k} / \mathrm{of} / \mathrm{k} æ \mathrm{t} /$. This makes the letter easier to remember than it would be if there were no such link, and similarly for the word's other letters. Patterns in this category can involve different types of linguistic units. The pattern involving «c> and /k/ is based on phonology. Other patterns are based on morphology, as when the knowledge that magician contains the morphological base magic helps to motivate the <a> spelling of magician's first vowel.

To learn about the patterns in an orthography, according to IMP, children apply their general-purpose learning mechanisms. One such mechanism is statistical learning ( $\sqrt{3} .1$ ): tracking how often and under what conditions events occur. For example, a learner of Portuguese may observe that many words end with «os» and that few end with <us>. The resulting knowledge may be implicit $(\sqrt{3} \cdot 3)$. Statistical learning can be slow, however, requiring many observations.

A second way of learning about patterns is being told about them. Adults may provide children with generic statements ( $\$ 1.3 .2$ ), such as that $/ \mathrm{m} /$ is spelled with «m», or with explanations about how a writing system works. These things, which may occur informally or as a part of formal literacy instruction, are likely to lead to explicit knowledge ( $(\sqrt[3]{ } \cdot 3)$. They can reduce the number of observations of individual words that would otherwise be required in order
to achieve generalizable knowledge．However，children need a fair amount of language skill in order to learn through language．

Learning about a writing system calls not only on children＇s general－purpose learning skills but also on their knowledge about language and its units．To understand the motivation for the 〈c＞in magician，for example，children must know that magician is related to magic．To understand the motivation for the ＜p＞in spit，children must conceive of the spoken word as beginning with a sequence of consonants and they must classify the second of these consonants as a／p／．Learning of orthography may be slowed by a difficulty in analyzing language into smaller units or in classifying these units in the way assumed by the writing system．

IMP predicts that children in literate societies，who have extensive exposure to print from an early age，will begin learning about some of its salient formal properties quite early．To begin learning about the patterns that relate written symbols to their linguistic functions，however，children must first learn that writing stands for something outside itself．They must treat language as some－ thing that can be symbolized，and they must break up spoken words into units of the type represented by their writing system．Given the difficulty of these tasks，IMP predicts that children will typically begin learning about the links between graphic forms and linguistic units only after they have begun to learn about some of the more obvious formal characteristics of writing．

We may get a better understanding of IMP by contrasting it with the other theories．The rote memorization view $(\mathbb{\$} 4.1)$ ，like IMP，sees the learning of orthography as calling on general－purpose mechanisms of learning and mem－ ory．The rote memorization view takes its ideas about these matters from the verbal learning tradition in experimental psychology，which focused on the learning of arbitrary sequences and arbitrary associations．IMP takes its ideas from a different tradition，which sees memory as constructive．According to this latter view，people supplement what they perceive and remember about specific events with generalizations they have developed on the basis of experi－ ence with multiple items or generalizations that have been conveyed to them through language．When people are learning material that is patterned rather than arbitrary－as writing systems are－such generalizations are important． For example，a child may be able to reconstruct missing letters from a spelling by using her knowledge of what spellings in her language typically look like． She may use her knowledge about the design characteristics of her writing sys－ tem＇s symbols to reconstruct a symbol shape that she has partially forgotten．

IMP acknowledges that rote memorization plays a role in learning about writing．For example， 4 －year－old Pam may learn to spell her name as a rote sequence，learning «Pam» no more easily than she would have learned 〈Jqz»． However，development involves going beyond rote memory．As Pam learns that « m » often stands for $/ \mathrm{m}$／and that a number of words other than her name end with＜am＞，the spelling of her name becomes motivated rather than arbitrary．She develops a large and redundant network of associations that specifies why her name is spelled as 〈Pam» rather than in some other way．

This network helps to anchor the spelling of her name and of other words in memory. Instruction should promote the learning of generalizations; it should not promote the idea that spellings are arbitrary sequences that can only be learned by rote.

Dual-route theory ( $\$ 4.2$ ) is based on the idea that spellers use rules as well as rote memory and that these are separate bodies of knowledge. According to the dual-route view, a spelling such as «choir» that can't be generated by rules must be memorized as a whole. IMP, in contrast, holds that patterns that go beyond a specific word are helpful even on words like choir. That is, even words that are typically classified as exceptional fit many of the patterns of a writing system.

According to some versions of dual-route theory, unconditioned rules linking phonemes to phonograms are the only possible motivations for spellings in alphabetic writing systems beyond whole memorized words. It is simple rules of this sort that should be taught to children. IMP acknowledges a broader range of patterns and a broader range of teaching targets. Some patterns involve the context in which a phoneme occurs. For example, the <ea> in head is motivated in part by the following phoneme (compare with words such as bread and dead), and the «a> in wander is motivated in part by the preceding phoneme (compare with wad and water). As the second of these examples shows, the effects of context aren't limited to rimes. In addition, patterns involving morphology are important for some alphabetic writing systems. For example, the fact that /fiz/ fees contains two morphemes helps to motivate the <S> spelling of the final /z/. According to IMP, children should learn about contextual patterns such as these.

Constructivists $(\$ 4.3)$ maintain that children build some hypotheses about writing that deviate markedly from the input to which they have been exposed. For example, learners of alphabetic writing systems are thought to hold for a period of time the hypothesis that single letters stand for syllables. This and other early hypotheses are universal, held by learners of greatly different writing systems. IMP stresses that children pick up patterns from the input to which they are exposed. Even at an early age, children who are exposed to different writing systems will show different patterns of performance. Whereas some of the hypotheses postulated by constructivist theorists, such as the rule that words must have a certain minimum length, are all-or-none, IMP holds that children acquire probabilistic patterns as well as all-or-none patterns. Whereas constructivists predict that a child at a given point in development applies the same hypotheses to all words, IMP suggests that children may perform differently on words that follow different patterns.

IMP is similar to phase theory ( $\$ 4.4$ ) in stressing the motivations that learners at different levels of skill find for spellings. Both theories claim that spelling depends on precise knowledge of words' written forms and strong and redundant connections between visual units and units of language. However, the theories make different claims about the order in which children learn about different patterns. Phase theory claims that children learn about patterns
involving letters' linguistic functions early on, during the partial and full alphabetic phases. Children learn about important formal patterns only later, during the consolidated alphabetic phase. IMP predicts, in contrast, that children learn about some of the more obvious formal patterns of writing at an early age. Because the difficulty of a pattern depends on a number of factors, including the statistical support for the pattern and the linguistic knowledge that it requires, IMP predicts a range of difficulty within the class of formal patterns and within the class of patterns relating forms to linguistic functions. Thus, although some patterns pertaining to the visual forms of spellings are learned at an early age, not all are. Whereas phase theory predicts a degree of consistency for a given child at a given point in development, IMP predicts that a child may spell different types of words rather differently at the same point in time.

IMP shares with single-route connectionist theories $(\mathbb{\$} 4.5)$ the idea that statistical learning is an important mechanism of learning. The two theories also share the idea that people use the same patterns when dealing with unfamiliar and familiar items-that there is no sharp dividing line between memory and invention. Whereas IMP acknowledges that children learn implicitly from exposure to multiple instances, it also acknowledges that they learn from language, including from statements that are designed to convey generalizable knowledge. Children benefit from feedback about whether their spellings are correct or incorrect, the sort of feedback that connectionist models receive, but they also benefit from prior teaching and from explanations about why their wrong answers are wrong. Whereas some connectionist theorists see people as ideal statistical learners, IMP acknowledges the linguistic and cognitive limitations that may cause even experienced spellers not to internalize all the patterns of a complex writing system.

### 4.7 Methods of Testing the Theories

The theories we have discussed seek to explain how children learn and use the writing system of their language. The theories must be tested against evidence. We present such evidence in chapters 5 through 12. In each of these chapters, we review the research on one specific aspect of orthography and evaluate the theories in light of the results. In this section, we preview the types of evidence that we will consider.

Some of the evidence that we will present comes from naturalistic studies. In such studies, researchers examine the writing that children produce in everyday situations. For example, researchers may study the spelling or punctuation in stories that children write in school. Other evidence comes from experimental studies, in which participants are presented with tasks in controlled situations. Characteristics of the task or the items are systematically varied. For example, researchers may dictate a list of words and compare performance on different types of words, or they may have children learn new spellings
under different conditions. An advantage of experimental work is the control that it offers. For example, children in an experiment can be asked to spell a large number of words of a particular type, whereas children in a naturalistic study may not choose to spell many words of that type. The range of tasks and outcomes that can be examined is often greater in experimental studies than naturalistic studies. For example, special equipment can be used in an experiment to examine how much time children take to begin spelling a word or how much time they take to write individual letters. Naturalistic studies, on the other hand, have the advantage of realism. The results are unlikely to reflect unusual strategies that children adopt in a contrived experimental situation.

Systematic studies of single individuals, or case studies, are sometimes useful as well. We will mention in later chapters several case studies of very young children, from whom it can be difficult to collect data in other ways. Observations from a single individual can also serve to illustrate the findings from other studies, and we will sometimes use such observations for this purpose. However, isolated observations from a single person don't allow for strong conclusions on their own.

Some researchers in the area of spelling, like some researchers in other areas, ask children to report on what they do and why (e.g., Farrington-Flint, Stash, \& Stiller, 2008). As mentioned in chapter 3, however, people can't always provide such reports and researchers can't always take the reports at face value. For example, a child who is asked how she spelled a word may say that she sounded it out because she considers this an acceptable answer, her teacher having told her to sound out words in order to spell them. Although introspective evidence doesn't always provide direct insights into what people do and why, the explanations that children hear from others and produce for themselves influence their learning. Thus, we will mention them at some points in the later chapters.

Testing a theory of orthographic development requires not only studies of children but also studies of language. Information is needed about the patterns in writing systems and about the patterns in the specific examples of writing that children see and attend to. For example, testing the theory that children spell words with more consistent rimes better than words with less consistent rimes requires data on how rimes are spelled in the words seen by children of particular ages (Ziegler, Jacobs, \& Stone, 1996; Ziegler, Stone, \& Jacobs, 1997). Testing the theory that context beyond the rime affects the spelling of phonemes requires data about how the spellings of phonemes vary as a function of context (Kessler \& Treiman, 2001). In the following chapters, we consider information of this kind when it is available.

### 4.8 Conclusions

In this chapter, we have introduced the major theories about orthographic knowledge and its development, and we have mentioned the implications of
each theory for teaching. In chapters 5 through 12 , we review data on the learning of various aspects of orthography, and we evaluate the theories in light of the evidence. In each of these later chapters, too, we briefly consider the implications of the research for teaching. We return to the theories in chapter 13, which summarizes the status of each theory in light of the evidence.

Many of the theories we have discussed concentrate on learning to spell in a strict sense: how children learn the spellings of specific words and how they attempt new words. But literacy learning begins well before children can write themselves. Children in literate societies are surrounded by examples of written language from an early age: on cereal boxes, in storybooks, on street signs, and so on. Young children see other people write and read and they hear other people talk about writing. Children learn many things about writing from these early experiences, including its general visual characteristics and the shapes of the individual symbols. This early knowledge sets the stage for later development. In the following chapter, we discuss young children's knowledge about the outer form of writing.

## chapter 5 Graphic Form

Writing has a double face. It is an object in itself-marks on a surface-and it is a representation of something other than itself-a linguistic structure. In this chapter, we discuss how children learn about the outer form of writing. We focus on the characteristics of words and texts, reserving a discussion of the shapes of the individual symbols for chapter 8 . We begin the chapter with a section on the graphic properties of words and texts. Although some information about this topic was presented in chapter 2, this chapter provides more detail about what children need to learn and how they might learn it. Later sections of the chapter review the research that has been carried out on children's learning about the outer form of writing. We consider the research findings with reference to the theories of literacy development that were discussed in chapter 4 , and we also consider the implications of the research for teaching.

Children in modern literate societies see writing in great abundance. Writing appears outside the home, as on signs, monuments, and graffiti, and within the home, as on labels for commercial products. Children see writing that is already made, as on T-shirts and in books, and they see writing as it is being produced, as when a mother writes her son's name for him. Some of the written materials that children see, such as newspapers, are of little interest to them. Other materials, such as storybooks, are designed specifically for children. As we will see, children in literate societies begin learning about the formal properties of writing at an early age.

### 5.1 Surface Properties of Writing

People are not born knowing about writing; they must learn about even its most basic properties. One of these is that writing is an artifact. It is something that people make, not a part of the natural world. This property is apparent in the fact that writing typically appears on a restricted set of objects that are made by
people or by machines that people control. The set of objects on which writing may be found includes paper, fabric, computer screens, and coins. These objects have surfaces on which marks may be made to appear. The marks may add to the surface, as with ink; carve it out, as with a chisel; or change its state, as when pixels change color on a computer monitor. The marks aren't intrinsic to the surface, like the stripes on a zebra. Children could learn that writing is an artifact by noting that it normally appears on the surfaces of things like paper and fabric and rarely on the surfaces of things like leaves or cats. Children could also learn about the artificiality of writing by watching it being made. This could allow them to learn that paper doesn't always come with writing on it; writing is put there by people or computer printers.

In addition to being artificial, writing is normally two-dimensional. The literal superficiality of writing is usually obvious from its presentation. In being two-dimensional, writing differs from most other objects that are familiar to children. Children must learn that it is the surface of the pages of a book, not the physical object as a whole, that is crucial for the message.

A third property of writing, at least of modern writing, is that it lacks iconicity ( $\$ 2.3 .1$ ). Written symbols aren't painterly representations of objects in the real world. Nor do they normally look like the shape the mouth assumes when it pronounces the corresponding linguistic form ( $\$ 2.3 .2$ ). Some earlier stages of certain writing systems, such as Chinese, did use symbols that were identifiable pictures of objects. Nowadays traces of iconicity are minimal, even among those Chinese characters that derived originally from pictures (Xiao \& Treiman, 2012). In this respect, among others, writing contrasts with the pictures that in children's experience often accompany it.

Still another property of modern writing is that it is sequential ( $\mathbb{2} 2.6 .1$ ). Although writing's sequentiality follows from its inner form, in that language is itself a sequence of words in time, the result is apparent even to someone contemplating only the outer form of writing. Writing has a train-like appearance that distinguishes it from most other artificial two-dimensional displays, including pictures and maps. Even written materials designed for young children, which may contain relatively little text, tend to arrange at least a few symbols sequentially.

Not only is writing sequential, but the lines of text are also normally straight. We call this property rectilinearity ( $(\mathbb{2} .6 .1)$. A surface containing a significant amount of text has a striate appearance, the text being arranged in parallel rectilinear rows or columns. The striate rectilinearity of text becomes explicit in the ruled paper on which people sometimes write.

Lines of text are made up of individual units, such as letters or other types of characters. Scripts vary in how easy or difficult it is to perceive that the units are freestanding, independent objects. This task is easy with Chinese or Japanese, where all the characters occupy a space of equal width (1). The task is more difficult with Arabic, where the letters in a word are of different sizes and generally connect to one another (2); both texts are Article 1 of United Nations, 1948). It is also more difficult with the connected writing that is sometimes
used as a cursive handwriting style in countries that use the Latin，Cyrillic，and Greek scripts．
（1）Japanese
すべての人間は，生まれながらにして自由であり，かつ，尊厳と権利とについて平等である。人間は，理性と良心とを授けられてお
り，互いに同胞の精神をもって行動しなければならない。
（2）Arabic


Yet another property of writing is that the units are drawn from a closed， finite set of symbols．This property follows from the fact that units of writ－ ing represent units of language，which are finite in number．The existence of repeatable units is probably more obvious to children in an alphabetic script，where there might be only two dozen different symbols，than in syl－ labic or logographic scripts，where there may be hundreds or thousands of different symbols．The existence of repeatable units may also be more obvi－ ous when the units are visually separate than when they join to one another． But even the most complicated script has several symbols that are especially frequent and often fairly simple as well．Recognizing these repeated sym－ bols may help children to understand that the set of symbols used in writing is finite．

Although writing is made from repeatable units，a given unit isn＇t usually repeated several times in succession in a line of text．A unit may occur twice in succession in some writing systems，as in the English word «ball» and the Finnish word «tuuli＇wind＇，but even this degree of repetition is rare in some other writing systems．In any writing system，it is very uncommon for a sym－ bol to repeat three or more times．Formally，XYZ but not YYY looks like a possible string of text．This property of writing reflects the fact that language isn＇t highly repetitious：a given linguistic unit is more likely to be followed by a different unit than by a repetition of the same one．A morpheme or a phoneme is sometimes repeated once in speech，as with the doubling or lengthening of vowels or consonants，but further repetition is unusual．Therefore，at whatever linguistic level writing operates，there is little repetition．

In any writing system，some units are more frequent than others．Also， some combinations of units are especially frequent，more frequent than expected on the basis of the units＇individual frequencies．Other combina－ tions of units are less frequent．For example，whereas «a＞and h$\rangle$ are com－ mon letters in English，the sequence «ah» is relatively uncommon．Such facts reflect in large part the frequencies of linguistic units，but children could learn about the patterns on a purely graphic basis，without knowing what the units represent．

Much of the writing that children see, whether on cereal boxes, billboards, or storybooks, is accompanied by realistic pictures. Pictures are like writing in being artificial and two-dimensional. But realistic pictures are much more iconic than writing is. Also, pictures aren't normally arranged in lines, and they aren't normally composed of units from a small set. In books for children, the pictures tend to be larger than the print. They are more likely to use color, shading, or hatching, and they vary visually in more ways than writing does. Further contributing to the differences between pictures and writing, written materials designed for children tend to use simple sans serif forms such as «E» rather than more decorative forms such as $\langle\mathrm{E}\rangle$ or $\langle\mathbf{E}\rangle$.

Many of the differences between writing and pictures reflect the fact that writing is meant to symbolize language, not usually to draw attention to itself. These considerations help to explain writing's visual blandness and limited internal variability. The typical features of writing become obvious when one looks at samples of writing that were designed to be noticed, such as artistic calligraphy, advertisements, or the letters in computer games or books that are designed to teach children about the alphabet. The letters here may be large and distinctively colored. The print may be oriented in an atypical way, such as along a diagonal in an advertising logo. It may even move, as in some computer games. Much writing, however, is self-effacing. It is less interesting and attractive than the pictures that often accompany it.

Some kinds of two-dimensional displays are more similar to writing than pictures are. For example, music notation is like language notation in being composed of nonpictorial units that are drawn from a restricted set. Of the symbol systems that children see, number notation is most similar in general appearance to writing. Like writing, it involves mostly noniconic symbols that are arranged in rows or columns and that come from a small set. With both numbers and letters, children sometimes encounter the basic symbols in a conventional order: $<12 \ldots$... or «A B C. ... 〉. In many societies, too, the shapes of numeric digits are rather similar to the shapes of the letters. But even when digits and letters rather look rather different, symbols from the two sets are often intermingled. This happens in texts, as in « 60 McCosh Circle», and even within words, as in the $<18 \mathrm{r} »$ of a text message. In many languages, moreover, people use the same words to describe production in the two systems. English speakers say that they write text or numbers, but they don't use write to refer to the production of a landscape.

Although language notation and number notation are similar in many of their formal properties, there are some differences. One difference is that repetition is more common for numbers. No language has words like «bbbbb», for example, but numbers like <99999> are perfectly fine. Single digits set off by spaces are quite common, but single symbols of writing set off by spaces are uncommon in many languages. Moreover, numerals rarely join to one another in the way that letters do in some styles.

To summarize, writing has a number of distinctive characteristics that are apparent on the surface. These include artificiality, two-dimensionality, lack of iconicity, sequentiality, and rectilinearity. In addition, writing is made up of a finite set of
units, some of which are more common than others, and a given unit rarely appears several times in succession. Having described some of the basic formal characteristics of writing, we now turn to children's learning of these characteristics.

### 5.2 Learning About the Surface Properties of Writing

Many of the visual characteristics of writing reflect the fact that it symbolizes language. However, children could begin to learn about the formal characteristics of writing without understanding their linguistic motivation. Indeed, even infants form categories on the basis of surface properties, for example categorizing pictures of horses as different from pictures of zebras (Eimas \& Quinn, 1994). Similarly, a US toddler may learn writing looks more like (3) than like any of (4-6)
(3) ipaov
(4) ррррр
(5) i
p
a
o
(6)

before he knows how writing symbolizes language and before he even knows that writing symbolizes language.

### 5.2.1 Artificiality and Two-Dimensionality

Children appear to learn at an early age that writing is an artifact produced by people rather than a part of the natural world. When US children talk about letters, as they sometimes do in everyday contexts before they are even 2 years of age, the verbs that they use are often ones like make or write, which focus on the process of production (Robins, Treiman, Rosales, \& Otake, 2012). Evidently, they have already learned that writing has to be made.

We suspect that children learn quite early about the two-dimensional nature of writing as well. Although we know of no research on this topic, we have noticed that young children are sometimes surprised and pleased to find an object that is shaped like a letter, such as a piece of wood in the shape of a T. This reaction may suggest some knowledge that writing isn't normally a three-dimensional part of the natural world.

### 5.2.2 Iconicity

Children who have begun to produce recognizable drawings, as typically happens after about 3 years of age, usually don't produce such drawings when asked to write (Gombert \& Fayol, 1992). That is, children's writing is normally
less iconic $(\$ 2.3 .1)$ than their drawing. In those cases in which children do draw in response to a request to write, this may reflect the knowledge that there is a conventional way to write that they don't yet know. As 5 -year-old Bethany explained, "you know, sometimes you can't write things like grown-ups so you have to make a picture" (Sulzby, 1985, p. 154).

Although children don't usually produce realistic pictures when asked to write, researchers in the constructivist tradition $(\mathbb{\$} 4.3)$ claim that they sometimes use iconic elements in their writing. For example, an Italian 5-year-old was reported to use three letters for both cagnolino 'little dog' and cane 'dog', but the letters were smaller for cagnolino (Pontecorvo, 1985). Researchers who have attempted to go beyond such anecdotal evidence have found some support for the idea that children sometimes produce iconic writing. In one study, Israeli 4- and 5 -year-olds tended to use more units to write a word meaning 'forest' than a word meaning 'tree', in line with the fact that forests contain many trees (Levin \& Korat, 1993). Overall, however, the writing that children produce is generally low in iconicity, as is the writing that they see around them.

### 5.2.3 Sequentiality and Directionality

Children appear to learn at an early age that writing is sequential ( $\mathbb{2}$ 2.6.1). Before they are 2 years old, US children sometimes talk about one letter as coming "before" another letter or as being "first." Children rarely speak in this way about pictures, showing an implicit understanding of an important difference between writing and pictures (Robins et al., 2012). Before their fourth birthday, US children who are asked whether various two-dimensional displays are writing tend to reject displays in which the elements aren't arranged along a line (Ganapole, 1987; Lavine, 1977). Additional evidence for early knowledge of sequentiality comes from a study in which US children with a mean age of 3 years and 9 months were asked whether versions of their given name had been correctly written. The children almost always accepted versions of their name in which the letters were arranged along a horizontal line. They were less likely to accept versions in which the letters were scattered in a random pattern or in which the letters were arranged along a diagonal line (Treiman, Cohen, Mulqueeny, Kessler, \& Schechtman, 2007). Similarly, the US 3 - and 4 -year-olds in another study tended to arrange units along a line when they wrote their names. The children were less likely to do this with longer stretches of writing, however (Puranik \& Lonigan, 2011).

Different writing systems have adopted different solutions to the question of whether writing should be organized along a horizontal or a vertical line ( $\$ 2.6 .1$ ). However, the only studies that we know of to have examined children's knowledge of this aspect of writing were done in societies that use horizontal writing. The children in the previously mentioned study by Treiman, Cohen et al. (2007), who had an average age of 3 years and 9 months, were more likely to accept a version of their given name in which the letters were arranged
horizontally than a version of their name in which the letters were arranged vertically. Another study examined the productions that were made by US children with a mean age of 3 years and 3 months in response to requests to write. Of the productions, $39 \%$ were horizontally arranged (Brenneman, 1996). This figure is relatively low, but it is higher than the $9.5 \%$ that was observed when the same children were asked to draw. Another researcher reported that US children between 3 and $3^{1 / 2}$ years of age showed a preference for the horizontal direction when they wrote their names (Hildreth, 1936). Together, these findings suggest that US children have some knowledge of the horizontal directionality of English writing before their fourth birthday. The preference for horizontal directionality becomes stronger as children get older. US children who were almost 5 years old produced horizontally arranged writing $70 \%$ of the time in one study, and the figure rose to $96 \%$ for children who were almost 6 (Brenneman, Massey, Machado, \& Gelman, 1996).

If writing is horizontal, must it go in one specific direction? In one study, US children with a mean age of 3 years and 3 months were more consistent in following a particular direction when they were asked to write than when they were asked to draw. That is, they showed some knowledge that writing is more constrained in its direction than drawing is (Brenneman, 1996). However, the majority of US 3 -year-olds don't produce writing in a consistent direction, and the same is true for Israeli 3 -year-olds (Brenneman, 1996; Tolchinsky-Landsmann \& Levin, 1985). We have observed that some children of this age curve around the side of the paper when they reach the end of a line rather than beginning again at the opposite side. The preference for a long, continuous line was manifested several times in the development of writing as boustrophedon text (\$2.6.1), and some individual children find it attractive as well.

Other studies have examined children's knowledge about the particular direction of writing that is conventional for their culture: left-to-right for some systems, including English, and right-to-left for other systems, including Hebrew. One way to assess knowledge of directionality is to ask whether children pay more attention to one edge of a word-the one that is defined in their culture as the beginning - than to the other edge. US children with an average age of 3 years and 9 months were less likely to say that their name was correctly written when they were shown a version of the name that differed from the correct name in the leftmost (or beginning) letter than a version that differed from the correct name in the rightmost (or end) letter (Treiman, Cohen et al., 2007). In Israel, where writing goes from right to left, 5 -year-olds sometimes identified as correct a classmate's name in which the final (leftmost) letter had been changed. Children were less likely to make this mistake when the initial (rightmost) letter had been changed (Levin \& Ehri, 2009). Another way to assess knowledge of directionality is to watch children write. In one study, only a minority of US children with a mean age of 3 years and 3 months honored the left-to-right direction of English when asked to write (Brenneman, 1996). In another study, US 4 - to 5 -year-olds printed $62 \%$ of their words from left to right (Brenneman et al., 1996)-more knowledge of directionality but not
complete. The figure increased to $95 \%$ for 5 - to 6 -year-olds. Similarly, a high proportion of 5 - to 6 -year-olds who are exposed to Spanish or to Hebrew write in the direction that is conventional for their culture (Manrique \& Signorini, 1998; Tolchinsky-Landsmann \& Levin, 1985).

All modern writing systems, and most past ones, start from the top of the page. There may be motoric and attentional reasons for this top-to-bottom preference, as mentioned in chapter 2 , whereas there are no overwhelming reasons for starting at the right or the left of the page. Given that there is less to learn in the case of top-to-bottom directionality, we suspect that it becomes consistent and conventional at a younger age than left-to-right or right-to-left directionality. Unfortunately, little information is available on top-to-bottom directionality in children's writing, other than a few reports that most 5 -year-olds write lines of print from top to bottom (Manrique \& Signorini, 1998; Sulzby, 1985).

### 5.2.4 Knowledge About Units

Writing is composed of units that are drawn from a finite set. These units are separate in some forms of writing, while in other forms they connect to one another. We turn now to studies that have examined children's knowledge that writing is formed of units. When children are asked to write, they sometimes produce unbroken wavy lines that don't appear to be composed of separable units. Children probably do this, in large part, because such forms are economical to produce. They don't require lifts of the writing instrument, as the production of separate units does. Some Israeli children of $3^{1 / 2}$ write using unbroken wavy lines (Tolchinsky-Landsmann \& Levin, 1985), and such productions are also common among French children of this age (Gombert \& Fayol, 1992). By $4^{1 / 2}$ years of age, according to the studies just cited, Israeli and French children generally use separate units when they write words and short phrases. Writing with unbroken wavy lines—what one child called "curspid" (Dyson, 1991)—may persist longer when children attempt to write a lot, at least in cultures in which children are exposed to some connected writing. Thus, the Argentinean 5 -year-olds in one study were more likely to produce wavy lines when they were asked to write stories than when they were asked to write single words (Manrique \& Signorini, 1998).

Children who know that the units of writing are drawn from a finite set should be able to reject as writing a display containing units from outside that set. US 3 - and 4 -year-olds appear to do this when they reject as writing strings that are composed solely of Chinese characters, symbols from Indian writing systems, or other symbols that look rather different from the Latin letters to which they have been exposed (Ganapole, 1987; Lavine, 1977; Treiman, Cohen et al., 2007). Such results suggest that children learn at an early age about some of the graphic properties that characterize the individual symbols of their script, a topic to which we return in chapter 8.

Written materials, even simple ones designed for children, tend to arrange at least a few symbols sequentially. When do children learn about this property? As early as 3 to 4 years of age, US children are less likely to classify as
writing displays that contain a single visual unit than displays that contain several units（Ganapole，1987；Lavine，1977）．For example，children are more likely to accept 〈PLVN〉 as something to read than 〈P〉．Similar results have been reported for children exposed to Spanish（Ferreiro \＆Teberosky，1982； Tolchinsky Landsmann \＆Karmiloff－Smith，1992）．As we discussed in $\$ 4.3$ ， such observations have led constructivist researchers to suggest that children at this early point in spelling development，which these researchers call the presyllabic stage，hold a minimum quantity hypothesis．Regardless of the writ－ ing system to which they are exposed，constructivists claim，children believe that written words must contain at least 3 or 4 letters．However，several stud－ ies have failed to support the idea that children have a strict lower bound on length that is the same for children exposed to all writing systems．The distri－ bution of length when 4 －and 5 －year－old learners of Portuguese，English，and Hebrew spell dictated words，it has been reported，approximates a bell－shaped curve．Children produce some 1－and 2－letter spellings，a number of 3－and 4－letter spellings，and some longer spellings（Pollo，Kessler，\＆Treiman， 2009；Tolchinsky－Landsmann \＆Levin，1985）．One would not expect to see a bell－shaped curve if children had a definite lower bound for length，as construc－ tivists claim．Moreover，the number of letters that children use in their spell－ ings is influenced by the length of the written words in their language．Thus， Brazilian 4－and 5 －year－olds who did not yet use letters to represent phonemes in any plausible or consistent way，or prephonological spellers，produced more 1 －and 2 －letter spellings than US children，in line with the fact that Portuguese uses more short words than English（Pollo et al．，2009）．This latter result sug－ gests that children are influenced by the formal properties of the writing in their environment from an early age．

Writing isn＇t highly repetitious：The same symbol rarely occurs multiple times in succession．Writing has this property because it represents speech． Stretches of speech in which the same linguistic unit occurs multiple times in succession are rare．However，children could learn about this property of writ－ ing based not on an understanding of writing＇s language－symbolizing function but by observing writing＇s outer form．Supporting the idea that children learn about within－word variation in symbol shape from an early age，US 3 －year－olds were less likely to accept as writing a sequence in which a symbol was repeated several times than a sequence of the same length that showed internal varia－ tion in the shapes of its symbols（Ganapole，1987；Lavine，1977）．Similar obser－ vations have been made among learners of Spanish and Italian（Ferreiro \＆ Teberosky，1982；Ferreiro，Pontecorvo，\＆Zucchermaglio，1996）．

Children also tend to avoid repeated elements in their own productions． Thus，Brazilian and US 4 －and 5－year－old prephonological spellers used double letters less often than would be expected if they randomly combined the letters that they knew（Pollo et al．，2009）．These results suggest that，even before chil－ dren have much knowledge about the sound－symbolizing function of letters， they know that adjacent symbols within a string don＇t normally have the same shape．Prephonological spellers in Brazil，where $1 \%$ of the two－letter sequences
in texts for children are double letters such as 〈ss〉, were even more likely to avoid double letters in their own productions than prephonological spellers in the US, where $4 \%$ of the two-letter sequences in texts for children are double letters (Pollo et al., 2009). This latter result suggests that infrequent use of double letters is a tendency whose likelihood of application is correlated with the statistics of the writing to which children have been exposed.

Young spellers appear to have some knowledge about the frequencies of other letter pairs besides double letters. Thus, the frequency with which Brazilian and US prephonological spellers use a pair of adjacent letters is related to the frequency with which the pair occurs in the written language to which they are exposed (Kessler, Pollo, Treiman, \& Cardoso-Martins, 2013; Pollo et al., 2009). It is related, too, to whether the two letters are adjacent to one another in the alphabet sequence-a sequence that is familiar to young children in both its spoken and written form.

Children also learn about how often individual letters occur. By the age of $4^{1 / 2}$ or so, US and Brazilian children choose letters in part on the basis of the letters' frequency in the written language to which they have been exposed, even when they don't yet choose letters on the basis of their sounds (Kessler et al., 2013; Pollo et al., 2009). For example, none of the letters that the Brazilian girl Ana uses when she writes luz 'light' as «EARS» appears in the conventional Portuguese spelling of this word. However, «A», «E», «R», and «S» are among the most common letters in Portuguese. The letter «a also appears twice in Ana's name, making it, for her, an especially frequent letter. Indeed, prephonological spellers from countries including Brazil, France, and the United States use letters from their given names at especially high rates when asked to write other words (Bloodgood, 1999; Gombert \& Fayol, 1992; Kessler et al., 2013; Pollo et al., 2009). Some researchers have taken such findings to suggest that children go through a period during which their only approach to spelling is to use letters from their personal name (Gombert \& Fayol, 1992). However, the research suggests that the productions of even prephonological spellers reflect the influence of a number of factors (Pollo et al., 2009). The letters from children's own names are one influence, but not the only influence.

The results reviewed in this section suggest that children use their statistical learning skills to derive implicit estimates of the frequencies of letters and groups of letters. These estimates influence the children's letter choices when writing.

### 5.2.5 Differences Among Types of Writing

Children must learn not only about the visual characteristics that hold true for all forms of writing but also about differences between types of writing. Some of these differences reflect the fact that different writers may favor different graphic forms. In some societies that have both writing styles with separate letters and writing styles with connected letters, for example, it is primarily older children and adults who use connected letters. The US 5 -year-olds observed by Sulzby (1985) appeared to have learned about this: When asked
how grown-ups write, a number of the children produced wavy lines or connected letters that differed from the disjoint forms that they typically produced. Similarly, Canadian 4- and 5-year-olds who were asked who could read various forms of writing said that adults but not children could read cursive writing and that both could read block letter writing (Bialystok, 1995).

In some writing systems, certain sorts of words have special graphic characteristics. In Chinese, personal names generally contain two or three unconnected characters, one for the family name followed by one or two for the given name. Many other common words consist of single characters. Starting around 3 years of age, Chinese children's productions of their names consist of more separate segments than their productions of single-character words, as when a girl aged 3 years and 8 months wrote her name as ( 7 ) and the character for "fire" (火) as (8) (Yin \& Treiman, 2013).
(7)

$\square$
Sometimes, different functions of writing entail different spatial arrangements. Systematic studies of children's knowledge of these differences are rare, but one researcher observed that Israeli 5- and 6-year-olds sometimes wrote lists with one word or phrase per line and stories with many words per line (Sandbank, 2001).

### 5.2.6 Differentiating Writing From Pictures and Numbers

When young children are asked to write their names or other words, they may produce scribbles that at first glance look similar to the scribbles that they produce when asked to draw. On closer inspection, however, the two sets of scribbles often turn out to be somewhat different. Support for this conclusion comes from studies in which adults are shown productions of children who have been asked to write and productions from the same children when asked to draw. When adults are asked to determine which productions come from which task, they perform above the level expected by chance, although by no means perfectly, with the productions of 3 -year-olds (Brenneman, 1996, for US children; Levin \& Bus, 2003, for Israeli and Dutch children; Treiman \& Yin, 2011, for Chinese children). Given the opportunity to observe several productions from the same child, adults perform above the level expected by chance even for 2 -year-olds (Treiman \& Yin, 2011). Before the age of 3, these results show, a number of children in literate societies make some distinctions between writing and drawing in their productions.

Several case studies shed light on when and how children learn to distinguish writing from drawing. One US girl at the age of 2 years and 2 months
would say "I draw bunny" or "I write bunny" with no clear difference in the products (Baghban, 1984). A few months later, some of the girl's productions were large and relatively unorganized scribbles, while others were smaller and more linear, and she used the conventional labels for the two activities. The US child in another case study began to produce some visible distinctions between writing and drawing at the age of 2 years and 4 months, a full year before he drew recognizable pictures (Grinnell \& Burris, 1983).

Young children's writings and drawings have been found to differ in a number of ways. As discussed earlier, children's writing is less likely to be iconic than their drawing is. Writing is more likely to be arranged on a line (Brenneman, 1996), and it is more likely to be small (Chan \& Louie, 1992; Treiman \& Yin, 2011). Drawing is more likely to have bounded, dense, and continuous marks and filled-in outlines (Brenneman, 1996; Treiman \& Yin, 2011). Children may lift their implements less frequently when they draw than when they write (Karmiloff-Smith, 1992). A child's drawings of different objects, even when not realistic, tend to look rather different from one another. In contrast, a child's writings of different words tend to look rather similar (Treiman \& Yin, 2011). Some of these differences between writing and drawing may be seen in the production of Sophia, a US child of $2 \frac{1}{2}$ (Figure 5.1 ). Sophia said that the large circular portion on the right was a drawing of a circle, and she identified the portion with small squiggles on the bottom and near the left as writing.

Some of the distinctions that young children make between writing and drawing reflect characteristics of the two systems that hold across languages and cultures. Other differences are more specific. For example, the squarish, angular forms that Chinese 2-to 6 -year-olds often produce for writing appear to reflect properties of Chinese characters that aren't shared by the symbols of some other writing systems (Chan \& Louie, 1992; Treiman \& Yin, 2011).

Children differentiate writing and drawing not only in the types of marks they make but also in the materials they use to make them. In China, children often use grid paper when learning to form characters in school. Chinese children who have not yet begun formal literacy instruction, too, are more likely to choose grid paper to write than to draw (Treiman \& Yin, 2011). In China and a number of other modern societies, colored crayons are associated with drawing


Figure 5.1: Sophia's picture.
and pencils and pens with writing. As early as 2 and 3 years of age, children tend to choose the appropriate instruments (Brenneman, 1996, for US children; Treiman \& Yin, 2011, for Chinese children). Although children sometimes use multiple implements while drawing a single object, they usually restrict themselves to one implement when writing a word (Treiman \& Yin, 2011).

The finding that children produce some distinctions between writing and drawing as early as 2 to $2 \frac{1}{2}$ years of age is impressive given that, by their second birthday, children have normally been using implements to make marks for only about 6 months (Cattell, 196o; Thomas \& Silk, 1990). Although it may seem to an observer that only the motor activity that is involved in mark making is important to a child, even $1^{1 / 2}$-year-olds spend more time scribbling with an instrument that leaves a trace than with one that doesn't (Berefelt, 1987; Gibson \& Yonas, 1968, as cited in E. J. Gibson \& Levin, 1975). That is, even toddlers have some interest in the visible traces that implements produce. They may compare their traces to those that they have seen other people produce and they may try, within the limits of their ability, to make them similar.

The studies that we have discussed so far on children's understanding of the differences between writing and drawing took the approach of examining the children's productions. In other studies, researchers ask children about productions made by others. Lavine (1977) reported that US children between the ages of 3 and 4, the youngest group of children she tested, rarely accepted line drawings as examples of writing. These children labeled pictures as the objects they represented, but they labeled letters, scribbles, and numbers as writing, letters, or similar terms. The US children tested by Brenneman (1996), who had a mean age of 3 years and 3 months, could point out writing and pictures when the two appeared together in picture books. The children performed above the level expected by chance when shown pairs of cards, one card in each pair with letters on it and the other with a line drawing of an object, and asked to find the card that had "writing and words and letters" on it (multiple wordings were used in case children didn't know some of the terms). The children's ability to distinguish writing from other types of marks wasn't limited to an ability to distinguish unrecognizable writing from recognizable pictures, for the children were just as good at distinguishing written words from musical notation as at distinguishing words from pictures. That is, the appearance of writing sets it off from visually dissimilar notational systems whose functions are equally mysterious to youngsters.

Young children's ability to differentiate writing from drawing in the perception and production tasks we have been discussing shows that they have begun to form separate categories for the two. It also shows that they are familiar with some of the conventional labels for the two types of productions and the labels for the activities that are involved in making them. In many languages, different verbs are used to refer to these activities. Even 1- and 2-year-old speakers of English are more likely to talk about "writing" a letter or "drawing" a picture than to talk about "writing" a picture or "drawing" a letter (Robins et al., 2012).

Visually, as discussed earlier in this chapter ( $\$ 5.1$ ), number notation is more similar to language notation than pictures are. US 3 -year-olds often accept strings of numbers as writing (Brenneman, 1996; Ganapole, 1987), and 4- and 5-year-olds sometimes do the same (Gòes \& Martlew, 1983). Even 6 -year-olds sometimes judge strings that include both letters and digits to be words (Bastien-Toniazzo, 1992). Children are less likely to make such mistakes with strings that mix letters with characters such as $\langle *$, and 〈\#, Although children sometimes confuse language notation and number notation, the Spanish 4- to 6-year-olds in one study appeared to know about some of the important visual distinctions between the two (Tolchinsky Landsmann \& Karmiloff-Smith, 1992). Thus, most of these children considered an isolated letter to be a poor example of writing but an isolated digit to be a fine number. Also, the children appeared to judge numerals that were physically linked to one another as poor examples of number notation, whereas they judged joined letters as acceptable for writing. The children seemed to consider a string of identical digits to be an acceptable number but a string of identical letters to be an unacceptable word.

Children's talk about language notation and number notation, although it has not been studied systematically, suggests some confusion between the labels that are used for the elements of the two systems. One US 3 -year-old of our acquaintance often talked about the "letters or numbers" that he saw in words, and a Spanish-speaking 4-year-old used the term letras 'letters' to refer to both the elements used for counting ("las letras de contar") and the elements used for reading and writing (Ferreiro, 1986). Some children have been reported to refer to letters as 'numbers' when they stand on their own, as digits often do, but to call them 'letters' when they are next to other letters in words (Ferreiro \& Teberosky, 1982).

### 5.2.7 Summary

Children in modern literate societies begin to learn about some of the outer or formal properties of writing as early as 1 or 2 years of age. They start to learn what writing looks like, and they start to learn how it differs from pictures. Children begin to do this before they have received any formal literacy instruction and before they understand much, if anything, about how writing symbolizes units of language. Overall, the results suggest, children learn about many aspects of writing's outer form quite early.

### 5.3 Theories

In this section, we consider how the findings we have reviewed fit with the theories of literacy development that were introduced in chapter 4. We have briefly discussed some of the findings with respect to constructivist theory, and in this section we provide a fuller discussion of the findings with respect to that theory, phase theory, and IMP. The other theories of literacy development that
were discussed in chapter 4 pay little or no attention to the early developments discussed here and so are not considered in this chapter.

The children who participated in most of the studies we have reviewed in this chapter are, according to phase theorists ( $\$ 4.4$ ), in the prealphabetic phase of literacy development. Children in this phase are said to lack an understanding of how letters stand for sounds. Thus, the US boy who produces 〈SSHIDCA〉 for welcome home (Bissex, 1980) is a prealphabetic phase writer. The only way that he can produce a message is to randomly string together letters that he knows. The research reviewed here suggests that, although such a child knows little or nothing about how letters signify sounds, he knows a number of things about writing. He appears to know that writing is artificial, two-dimensional, noniconic, and horizontal, and even that it goes from left to right. He appears to know that $\langle S\rangle$ is one of the shapes of his writing system, and he doesn't use other shapes, like < $\phi$. Phase theory has focused on how children grasp that the symbols of alphabetic writing systems represent phonemes and how they spell words after they have gained this insight. The theory has devoted little attention to the knowledge about writing that children possess before they begin to use writing to represent units of language. The results reviewed here suggest that even young children know a number of things about the outer form of writing.

Constructivist theory ( $\$ 4.3$ ) has paid more attention to children's early writing and the knowledge that underlies it. The findings we have reviewed support the constructivists' general claim that children in modern literate societies who are in what is called the presyllabic stage know a good deal about writing. However, the findings don't support a number of the constructivists' specific claims about what young children know and how they learn it. According to constructivists, young children postulate a strict lower bound for the number of letters in a word: the minimum quantity hypothesis $(\$ 4 \cdot 3)$. This lower bound is largely independent of the writing to which the children have been exposed. The data suggest, however, that children don't postulate a strict lower bound. Instead, the distribution of word lengths in children's productions is influenced by the distribution in the writing to which they have been exposed. The data are consistent in some ways with the constructivists' within-word variation hypothesis. That hypothesis states that children prefer sequences that fit the structural description XYZ, with no repetition of letters, to those that fit the description XXX, and we have seen evidence for such a preference. However, the data aren't consistent with the idea that children construct the within-word variation hypothesis largely on their own. Thus, whereas constructivists claim that Italian children reject words with double letters to the same extent as Spanish children even though Italian contains many more words with double letters than does Spanish (Ferreiro et al., 1996), experimental data suggests that children's use of repeated letters is linked to the degree of repetition in the writing to which they have been exposed.

Some researchers in the constructivist tradition, and others who have been influenced by it, claim that children's early writing includes
features that are common to all writing systems, such as being composed of units that are placed along a line. Over time, children begin to include features that are specific to the writing system to which they are exposed, such as left-to-right directionality for users of English and Spanish (Puranik \& Lonigan, 2011; Tolchinsky, 2003). This universal-to-specific hypothesis fits with the constructivist view that children's initial ideas about writing are largely self-generated. Children in all cultures may place units along a line, for example, if they believe that writing should reflect the fact that speech extends through time in a continuous stream. However, the research we have reviewed shows young children honor some script-specific and culture-specific features as well as some universal features. For example, US children learn quite early about the horizontality of English, a script-specific feature. Children's learning about the formal properties of writing appears to be just that: formal. The order in which children learn about the outer properties of writing is determined by such things as the visual salience of the property and the amount of evidence for it in the writing to which children are exposed. It isn't determined by whether a property is specific to a particular culture or writing system or whether it is universal.

Our theory, IMP $(\mathbb{\$} .6)$, proposes that children learn about two general types of patterns that characterize writing. Some patterns are formal; they involve the graphic appearance of words and texts. Other patterns involve the links between units of writing and units of language. The research we have reviewed suggests that children in modern literate societies learn about some of the more salient formal properties of writing at an early age. When a US boy of 3 years and 8 months produces (9) when asked to write chair, he shows some understanding of what writing looks like.

## (9) 2222280

We might not want to say that the boy is truly spelling, for he isn't using letters of the Latin alphabet to represent sounds. However, he has some knowledge about the formal characteristics of writing that provides a foundation on which to build. Consistent with IMP's emphasis on multiple patterns, the letter choices of young children are influenced by a number of formal patterns. These include the frequency of individual letters, the frequency of pairs of letters, the conventional order of the alphabet, and the letters in the children's names. Knowledge about the visual patterns that characterize words and texts constrains the writing that children produce and allows them to rule out such things as realistic line drawings or sequences such as «BBBBB» as examples of writing.

The results we have reviewed support IMP's claim that children use their general-purpose statistical learning skills in learning about the outer form of writing. Thus, children don't postulate a strict lower bound on word length, as constructivists claim. Rather, they learn about the distribution of lengths in the written words that they see. As another example, children learn that some symbols of writing are more common than others. To use their statistical learning
skills to learn about the visual properties of writing, children needn't know that writing represents language. They needn't conceptualize language in terms of smaller units. They needn't understand spoken explanations that are provided by adults. Thus, IMP fits well with the fact that children in modern literacy societies learn about some of the salient graphic properties of writing as early as 2 or 3 years of age.

### 5.4 Teaching

We have seen that children learn about many aspects of the outer form of writing without explicit teaching. However, teaching could potentially speed their progress. In this section, we consider how young children's environments can be structured in order to aid learning.

One foundation of the whole-language philosophy, according to which children can and should discover many things about writing on their own ( $\$ 1.3 .1$ ), is that homes and classrooms should be filled with print. Discussions of print-rich homes and classrooms might be taken to imply that children need only be exposed to writing in order to learn about it. However, children can't use their statistical learning skills in order to learn about an object or an event if they don't attend to it. Babies are built to find speech interesting (Schultz \& Vouloumanos, 2010), but they aren't built to find writing interesting. Much writing is visually bland-just lines of small black shapes on a white background. Thus a first step in helping children to learn about the visual properties of writing is ensuring that they attend to it and engage with it.

Reading to children is one potential way to engage them with print. Some researchers and educators have claimed that reading books aloud to children who can't yet read themselves is an effective way for them to learn about the visual characteristics of print (Schickedanz, 1978). Reading to children has many benefits, including exposing them to language and concepts that they might not otherwise encounter and providing an intimate and enjoyable activity (Aram \& Aviram, 2009). However, reading aloud to children who can't read on their own isn't an efficient way for them to learn about the visual characteristics of writing. The writing in a book is less interesting to a child than the adult's speech, and less interesting than the pictures that usually accompany the writing. Indeed, children who don't know how to read spend much more time looking at the pictures than at the print when being read to from storybooks and alphabet books, and they remember the pictures better (M. A. Evans \& Saint-Aubin, 2005; M. A. Evans, Saint-Aubin, \& Landry, 2009; M. A. Evans, Williamson, \& Pursoo, 2008; Justice, Skibbe, Canning, \& Lankford, 2005). Further evidence of young children's lack of interest in the print in books is that they are less likely to ask questions about it than about the pictures (Yaden, Smolkin, \& Conlon, 1989). When parents read stories aloud to young children, they don't often draw children's attention to the print by talking about it or by tracking it with their fingers (Justice \& Ezell, 2000; Phillips \& McNaughton,
1990). Even a child who knew that the print rather than the pictures tells the story, and even a child who was attempting to match specific printed words to spoken words-and many young children don't yet know these things-would have difficulty determining which word the adult was looking at because the words are generally close together. For all these reasons, there is a limit to the amount that young children can learn about print by being read to in the typical way from typical children's books.

One way to increase children's attention to print is to make it more attractive. Letters can be large or decorative, or words can be embedded in pictures. Some conventional and electronic books for children include such print, as do many of the signs and advertising logos that are sometimes referred to as environmental print. Such writing is more likely to attract children's attention than more typical writing, although it still loses out to pictures when it appears together with them in books (Justice et al., 2005). There are several potential drawbacks to attractive and attention-grabbing print, however. Decorative writing is harder to discriminate from pictures than typical writing. When writing is colorful and attractive, it may be harder for children to understand that writing's main value is as a symbol.

Another potential way to increase the amount that children learn about print while being read to is for parents or teachers to talk about the print or point to words as they read them (M. A. Evans et al., 2008; Justice, Pullen, \& Pence, 2008). Similarly, each written word in an electronic book can be highlighted as the corresponding spoken word is pronounced. These things may draw children's attention to the print and increase their knowledge of its characteristics (Justice \& Ezell, 2000). However, such activities might also detract from conversations about the story or children's enjoyment of being read to. We know of no formal studies on this topic, but one woman told us that, when she tried running her fingers under the words while reading to her daughter, the girl pushed the mother's fingers away because they covered some of the pictures.

Watching people write or trying to do so oneself are other ways to learn about writing, and they may not involve pictures or stories that can draw attention away from writing. As mentioned in $\int 1.1$, children tend to watch and imitate the purposeful actions of other people with whom they identify, even when they don't understand why these people are performing these actions (Lyons, Young, \& Keil, 2007; Yang, Sidman, \& Bushnell, 2010). A 3-year-old isn't likely to be interested in a pencil that is lying on a table. However, she becomes interested in the pencil when her mother picks it up and makes marks with it, saying that she is writing a grocery list. The girl doesn't know why her mother makes certain types of marks rather than others or why her mother starts at the top of the page and goes down. The child's lack of knowledge doesn't stop her, though, from trying to reproduce these things when she writes her own pretend grocery list. Children are often overconfident about what they know and what they can do, and this means that they are often willing to try writing even when their productions deviate in many ways from adult models. Indeed,
parents of young children often encourage them to write. In one study, parents of US $1^{1} / 2$ - to 5 -year-olds rarely said things like "You can't write yet" (Robins \& Treiman, 2009).

Watching people write can provide stronger evidence about certain formal properties of writing than looking at writing that is already made. Consider the property of directionality. Lines of print that hug the right side of a page and that vary in how far they extend to the left suggest that the print starts on the right, as in Hebrew. But such visual cues may be subtle. When margins are justified, as they often are in printing, only the last line of a paragraph provides information about left-right directionality. When there is a single word and a single picture in the middle of a page, as in many picture books for young children, no visual cues to directionality are present at all. When an Israeli child watches another person write, however, he can see that the person starts on the right and proceeds leftward.

Children can learn about objects and events not only by observing them but also by being told about them. Generic statements such as "writing goes from right to left," if understood, give children an opportunity to learn about a property of their writing system from a single utterance. A parent might not normally say something like this to a 2 -year-old, but comments such as "this letter comes first," which US parents do sometimes make to children as young as 1 or 2 , may alert children to the sequentiality of writing (Robins et al., 2012). As another example, hearing some marks called pictures and others words or some marks called numbers and others letters may alert children to differences among the marks that the children might have otherwise ignored. Hearing different verbs for the different activities may be helpful, too. As children get older, talk about the graphic characteristics of writing may become more explicit. For example, a teacher may explain that writing should start at the top of the page and go down. In one study, US children of around 5 years of age showed some benefits from teacher-led instruction about this and other graphic characteristics of writing (Reutzel, Oda, \& Moore, 1989).

When direct instruction in reading and writing is provided, children are often assumed to know certain things. For example, children may be taught to use certain letters to represent certain sounds, but they may not be taught to arrange the letters from left to right along a line, on the assumption that they already know how to do so. Although children often learn this and other things informally at an early age, difficulties can arise if they haven't. Testifying to the difficulties that can occur when people lack important background knowledge, consider the signs that were posted some years ago by mine owners in South Africa in an attempt to enlist the help of the miners, most of whom were illiterate, in keeping the tracks clear of rocks. The left panel of the sign had a picture of a rock on the track, the middle panel had a picture of a miner putting the rock in his cart, and the right panel had a picture of the miner moving along with the rock in the cart and the track clear. The designers of the signs, who wrote and read left to right, assumed
that the signs would be easy to understand. But a number of miners didn't understand them. They interpreted the sequence of pictures from right to left, taking the rocks out of their carts and putting them on the tracks (Dreyfuss, 1972). Similarly, teachers may find that certain things, such as idea of beginning to write at a certain point on a page, aren't obvious to all children.

### 5.5 Conclusions

Writing has many visual characteristics that distinguish it from other types of marks, such as pictures. As early as 2 years of age, children in modern literate societies begin to learn about some of the salient visual features of writing and try to reproduce these features in their own attempts to write. Children's ability to do this is in many ways impressive, testifying to their perceptual skills and statistical learning abilities. A $21 / 2$-year-old who can distinguish at a glance between convertibles and other cars uses many of same skills to distinguish writing from other types of marks, even though marks on paper are less interesting and make less noise than vehicles. No conceptual leap or radically different mode of thinking is required.

Young children's knowledge about the outer form of writing, although impressive in some ways, is less impressive in others. Young children focus on the appearance of the written product and the mechanics of production; they may not yet understand that writing symbolizes language or how it does so. Writing doesn't truly become writing until these things are understood. In the next chapter, we examine young children's knowledge about the deeper properties of writing, in particular the fact that it symbolizes language.

## chapter $\quad$ Symbolic Function

THE MOST FUNDAMENTAL CHARACTERISTIC of all full writing systems is that they are glottographic ( $\mathbb{\int}$ 2.2.2). Because writing isn't part of the human genetic endowment, children must learn even this most basic property at some point. When and how do children learn that writing gains its meaning indirectly, by virtue of the fact that it represents language? What ideas do they have about the function of writing before they learn that it is glottographic? How can children be helped to understand that writing stands for language? In this chapter, we review the research on these topics. We consider its implications for theories of literacy development and also for teaching. The shortness of the chapter reflects not the lack of importance of the topic but the sparseness of the research.

### 6.1 Learning That Writing Stands for Something Outside Itself

Writing is a symbol. It is a system of conventional shapes that are intended to represent specific meanings. A first step in learning that writing is a symbol is learning that it is produced intentionally by people. That is, children must learn that writing is an artifact rather than a part of the natural world. We suggested in $\$ 5.2 .1$ that children in literate societies learn about the artificiality of writing as early as 1 to 2 years of age.

As early as age 2 , children who encounter novel artifacts want to know why they are created, what purpose they serve (Kemler Nelson, Chan, \& Holt, 2004). Children might at first surmise that surfaces with writing on them are utilitarian objects, like beds and toothbrushes. For example, children might think that newspapers are meant to shield people's eyes from light when they doze in chairs or that posters are meant to cover stains on walls. However, children's experiences with writing suggest that, even though objects with writing on them can serve such purposes, they have other functions. For example,
older sister get upsets when juice spills on a scrap of paper that has marks on it. Mother brings a piece of paper with marks on it to the grocery store, looks at it, and suddenly remembers what she wanted to buy. Father, when asked how far the earth is from the sun, looks at a computer screen and after a few minutes gives an answer. Such experiences may suggest to children that papers, books, and screens whose surfaces have certain kinds of marks on them have value beyond themselves.

Some marks are placed on objects intentionally as decoration. For example, the stripes on wallpaper are put there in order to make a room more beautiful. Some examples of writing invite similar ideas. For example, a poster advertising a soft drink may have colorful and attractive writing on it, making a child think that it could have been placed on the wall of a subway station because of its beauty. But could a poster spelling out the regulations for subway passengers, which is composed of lines of small black marks on a white background, have been placed in the subway station because of its beauty? Probably not. Visually, print is less gripping than most pictures, photographs, or maps. The blandness of most writing-the fact that it affords little other than looking, and that it isn't as attractive for that as pictures-is a drawback in that it doesn't draw children's attention to print. However, the blandness of writing may help children to understand that writing's main value isn't as decoration but as symbol. From this point of view, normal print serves children well. Children are less well served by the eye-catching writing in product logos, advertising, and other environmental print ( $\$ 5 \cdot 4$ ).

Research supports the idea that material objects that aren't interesting or attractive are more readily interpreted as symbols than things that are. When a young child sees a small-scale model of the room in which she is standing, she may consider the model a plaything rather than a representation. When an adult hides a miniature toy in the model and tells the child that a larger version of the toy is hidden in the real room, the child may be unable to use the relation between the model and the room to find the toy (DeLoache, 2000). The difficulties increase when the child plays with the model beforehand, increasing its salience as a plaything. The task becomes easier when the model is placed behind a window, where the child can't touch it. Normal writing is less interesting and attractive than a three-dimensional model, and this may help children to understand that it stands for something outside itself.

### 6.2 Learning What Writing Stands for and How

Children may learn early on that writing stands for something outside itself, but what does it stand for, and how does it represent its object? Young children may consider writing to be a method of semasiography ( $(\mathbb{2} 2.2 .1)$. That is, children may take writing as a first-order symbol, like a picture, rather than as a second-order symbol (Vygotsky, 1978). A person might be associated with a letter
or a letter sequence, on this view, just as he might be associated with a picture of himself or with the blanket that he often carries.

Supporting these ideas, English-speaking children below $3^{1 / 2}$ years of age in one study never talked about writing function words (grammatical words) like no, with, and of, or entire phrases, as they would be expected to do if they grasped that writing could stand for any and all language. The children talked instead about writing things such as cat and tomato, concrete objects (Robins \& Treiman, 2009). Other reports suggest that some children in North America and India are less willing to write a phrase like no cats than a phrase like two cats or red cat (Homer \& Olson 1999; Ramachandra \& Karanth, 2007). If writing represents objects directly, children may think, how can there be any writing if there aren't any cats? Additional evidence that young children associate writing directly with people and objects comes from anecdotes and case studies. The subject of one case study, Lucas, appeared to believe at the age of 2 years and 4 months that letters belonged to animate beings. When he saw the written word «Paris», he said that the «P> was for Papa, the $\langle\mathrm{r}\rangle$ for Lucas, the <a> for Sonia, and the «s> for Mama (Sinclair \& Golan, 2002). A child of around 5 or 6 appeared to show a similar belief when he referred to «D> as both dummy and Lester. These were two labels for the ventriloquist's dummy that the child had learned to associate with this letter. The child seemed to assume that the letter denoted the dummy directly and could therefore be called by either of those labels (Dyson, 1984).

The idea that writing stands directly for animate beings and concrete objects may be promoted by how parents talk with children about writing. For young children in the United States and the United Kingdom, quite a bit of the talk that they engage in with their parents about writing concerns the writing of personal names, especially the child's name (Robins \& Treiman, 2009; Robins, Treiman, \& Rosales, 2013). When parents talk about writing words other than names, these are often picturable objects. Moreover, English-speaking adults often describe the associations between letters and people or objects using the word for, as when Lucas's parents tell him "/عl/ is for Lucas." What adults mean is that $/ \varepsilon l /$ is the name of the first letter in Lucas's name, but what the child may infer is that this unit of print belongs to and is associated with him.

Alphabet books and songs, which we discuss in more detail in $\S 7.2$, may also encourage the idea that letters belong to or stand for animate beings or concrete objects. Thus, alphabet books are read as saying things such as " $\langle A\rangle$ is for ant" and " B$\rangle$ is for beetle." The Alphabet Song that is used in the United States includes the phrase "now I know my ABCs," and US parents and children sometimes talk about $\langle\mathrm{A}\rangle$, $\langle\mathrm{B}\rangle$, and $\langle\mathrm{C}\rangle$, in particular, as belonging to children (Robins et al., 2012).

If writing stands for people or objects directly, what is the nature of the link between a piece of writing and its object? In some cases, a sign is iconic in that it physically resembles its object. For example, a drawing of a bear resembles an actual bear. Young children are familiar with iconic representations. For
example, the remote control that a child uses as a telephone in pretend play is similar in size and shape to a real telephone. Indeed, young children more readily engage in pretend play when the substitute object is physically similar to the referent object than when it is quite different (Elder \& Pederson, 1978). Children who encounter two-dimensional marks that appear to have been placed intentionally on a surface and that seem to serve a purpose other than the decoration of that surface may look for similarities between the marks and objects in the real world. The search for visual iconicity bears fruit with many two-dimensional artifacts, including drawings and photographs. However, writing rarely looks like a picture of anything. The English word <apple» is a string of marks, usually black, that are arranged on a horizontal line. The marks aren't normally arranged in a circle, and they aren't usually red or green. Even a cursory examination shows that the written word isn't iconic in a holistic way. None of the individual marks within the string looks much like an apple, either. As we saw in $\mathbb{\$} .2 .2$, children in modern literate societies know from an early age that writing is much less iconic than drawing.

Another possibility is that writing connects to its object through spatial or temporal contiguity. As we discussed in $\mathbb{\int 2 . 3 . 1}$, Peirce referred to a sign that works this way as an index, pointing out that an index need not be intentionally produced (Peirce, 1958). For example, an adult takes an empty grocery bag and a receipt on the kitchen as a sign that groceries have been purchased and placed in a nearby cupboard. He takes smoke as an index of fire. In a similar way, a child may take 〈girl> in a picture book to represent the concept of a girl because of its proximity to a picture of a girl. Experimental evidence that young children's responses to some types of print are more influenced by the context in which the print occurs than by the print itself comes from a study with US children of around 5 years of age (Masonheimer, Drum, \& Ehri, 1984). The children usually identified «McDonald's» as such when it was next to the golden arches, even if the final $\langle\mathrm{s}\rangle$ had been changed to $\langle\mathrm{f}\rangle$. If no arches were present, the children's ability to identify the print dropped sharply.

The moving word task provides additional evidence that children up to the age of around 5 sometimes use nearby pictures, when available, to specify the referents of printed words. In this task, a printed word such as «girl» is placed under a picture of a girl, but then is moved, as if by accident, to under a picture of a tree. Some 3- to 5-year-old learners of English say that the word now says tree (Bialystok, 1991; Bialystok \& Martin, 2003), and similar results have been reported among learners of Japanese (Takahashi, 2012). Young Chinese children sometimes make these errors even when presented with characters that resemble to some extent the objects that they represent (Bialystok \& Luk, 2007). Evidently, the degree of iconicity in even the most iconic Chinese characters can't compete with the degree of iconicity in a realistic picture. Threeand 4 -year-olds are more likely to change their interpretations of words in the moving word task than to change their interpretations of pictures in an analogous task (Apperly, Williams, \& Williams, 2004). A child will sometimes err in the moving word task even when an adult writes the word in front of the child
or even when the child writes the word herself (Bialystok \& Martin, 2003). Contiguity to a picture is so important to young children, evidently, that it can outweigh the intention of the writer.

A child who uses contiguity to a picture or an object to make an inference about the meaning of print has some chance of being correct-a better chance than a child who hypothesizes that a long stretch of print represents a big object or that a stretch of print that contains «o»s represents a creature with wide-open eyes. Indeed, indexical relations based on spatial contiguity are common in commercial print, as when «Pepsi» appears on the can that contains the drink. Spatial contiguity is also common in the many books for young children where each page shows a picture of an object and the corresponding written word. Temporal contiguity is present too, if the child looks at the picture and then at the word. In many cases, a child who makes an inference about the meaning of print based on spatial or temporal contiguity to a picture or an object will find that inference to be correct. These considerations may explain why interpretation of writing based on contiguity lasts longer than interpretation of writing based on iconicity.

Treating writing as an index doesn't always work, however. Some of the print that young children see isn't accompanied by pictures. This includes the print in books designed for older children and adults and the print on certain signs, such as those that give the names of streets. Young children may notice that other people nevertheless get meaning from such print. They may notice that the meaning may not relate to anything near the print in space or time, as with a directional sign in St. Louis indicating the mileage to St. Charles. In storybooks, too, the text may go beyond what the pictures suggest. As children observe that a story can go beyond the pictures and that people can gain information from bare writing, they may come to understand that contiguity doesn't always offer a way to interpret writing.

Children's printed names are of particular interest to them, and their experiences with names may help them to learn that writing isn't always an index. For example, Joe may observe that his written name sometimes appears near his person or his depiction, as when his name is next to his photograph in the nursery school portrait gallery or on his T-shirt. However, the name still stands for Joe when it is some distance away from him. Personal names are, in their portability, unlike words such as Crest, which children rarely see anywhere other than on the toothpaste tube or the toothpaste box. Consistent with the idea that children's experiences with proper names help in learning that contiguity doesn't govern the interpretation of print, children perform better on the moving word task with proper names than with other kinds of words (Bialystok, 2000).

Children must learn that the link between a piece of writing and its referent involves conventions that are shared by groups of people. As early as $1 \frac{1}{2}$ or 2 years of age, Chinese and Japanese children are more likely to decline a request to write than a request to draw, and they are more likely to say that writing is difficult (Yamagata, 2007; Treiman \& Yin, 2011). Such reactions suggest
some understanding on the part of children that writing is governed by conventions that they don't yet know, conventions that are stricter than those that govern drawing. Compatibly, US children appear to be happier and more carefree when they draw than when they write (Brenneman, Massey, Machado, \& Gelman, 1996). The observation that a young child will sometimes ask an adult "What did I write?" after producing a writing-like scribble also suggests some knowledge on the part of the child that the interpretation of writing is constrained by certain conventions that only the adult knows (Clay, 1975).

A number of the conventions that govern writing reflect the fact that it represents language. Because a specific piece of writing represents a specific unit of language, the meaning of the written word «cat» must be reported as cat /kæt/. It wouldn't be acceptable to read this word as kitty /'kıdi/. A drawing of a cat, in contrast, could be described as depicting a cat, a kitty, or a puss. The US children in one study were shown a card and were told that it had the word for cat written on it, for example. Children of $3^{1 / 2}$ years and older often didn't accept kitty as an alternative label for the written word. When children were shown a card and were told that it had a picture of a cat on it, they were more likely to accept kitty as an alternative label (Treiman, Markson, Hompluem, \& Gordon, 2013). Learning about the importance of exactness in reporting the meaning of writing may be an important step in learning how it works.

Children could potentially learn about the importance of exactness for writing by observing that books are usually read the same way each time. Especially with books that use rime or alliteration, adults don't normally change the words when reading aloud to children. They read the first lines of the children's book The Cat in the Hat as "I sat there with Sally. We sat there we two," and a child who is familiar with the book would be surprised or even upset to hear "Sally and I sat there. We sat there together." To infer that the printed words in the book stand for specific linguistic units, however, children must know that the print rather than the pictures govern what people say when they are reading aloud. Young children don't always know this. Supporting this idea, many of the young 3 -year-olds in one study pointed to the print when asked to "find writing" in a picture book but didn't reliably point to the print when asked where one should read (Brenneman, 1996). The pictures and the print in books are close together, and children can't be sure which one an adult is looking at while reading. Thus, whereas a child may be able to infer that sausage is a kind of food rather than a kind of toy if an adult stares at a child's uneaten plate of food while saying "Eat your sausage," eye gaze isn't a very useful cue in the case of picture books. Experience with words and letters that aren't accompanied by pictures is probably more useful than experience with picture books in learning that a specific piece of writing represents a specific piece of language.

Hearing written words discussed as "saying" things could help children to learn that writing is glottographic. Parents say things like "This says cat" in reference to printed words starting from when children are as young as $1^{1 / 2}$ years of age (Robins \& Treiman, 2009), and US children begin to talk this way without prompting from parents when they are around 3. Children might learn
that the verb says has a special idiomatic meaning when applied to writing, in much the same way that they learn that pull my leg means 'trick me'. However, this use of says might help children to infer that a written word stands for a specific unit of language-that writing is quoted speech. Certainly, 2- and 3-year-olds can use subtle differences in phrasing as a guide to meaning, as when they make different inferences about zav when this novel word is used in the sentence "This is a zav" versus "This is some zav" (Bloom, 1996).

Hearing talk about the writing of entire phrases or sentences or about the writing of function words may also help children to learn that writing represents any and all speech. Parents don't discuss the writing of function words like if and from very often when talking with children, but they occasionally do this with children over the age of $3^{1 / 2}$ (Robins \& Treiman, 2009). Around this same age, children occasionally begin to do the same. One way to promote children's understanding of writing's glottographic nature may be to increase talk of this sort. For example, a parent or preschool teacher who is helping a child to write a thank-you card might say that from should be written in one spot and to in another.

Writing's sequentiality ( $\$ 2.6 .1$ ) could potentially help children to learn that writing represents language. This visual feature may provide a clue that writing maps onto something that is itself sequenced, language being a potential candidate. The sequentiality of writing becomes even more apparent when children see adults running their fingers under a text while reading or when they see adults producing one letter at a time while writing. In addition, as mentioned in $\mathbb{\$ 5}$.4, adults highlight the sequentiality of writing when they say things such as "This letter comes first" (Robins et al., 2012).

Another visual characteristic of writing that may provide a clue to its glottographic nature is that it involves a relatively small number of units that repeat themselves in different orders. If children notice this, and if they conceive of spoken language as a sequence that also includes a relatively small number of units that repeat themselves in different orders, the structural similarities between writing and language may help them grasp the relation between the two. To make such inferences, though, children must conceptualize language as a string of discrete units, something that is difficult to do, especially for alphabetic writing systems. Discussion of specific letters as standing for specific sounds provides a more direct way of teaching children about the glottographic nature of writing and about the specific conventions that link units of language to units of writing. US parents don't often talk about letters as standing for sounds with children less than 5 years of age, and they don't often question children about such matters (Robins et al., 2012, 2013). However, children may be exposed to such discussions in preschool and on television programs or computer games that are designed to teach them about writing. Once formal literacy instruction begins, there is much discussion in phonics programs ( $(\mathbb{1} 1.3 .2$ ) of letters as "saying" sounds and written words as "saying" spoken words. Exactness is emphasized, so that a child may be corrected if she writes cat as «kitty> or reads «couch> as sofa. Such practices are less common
in whole-language classrooms, which are based on the idea that children can and should discover the glottographic nature of writing based on discovery and informal teaching ( $\$ 1.3 .1$ ). Praising a child who reads «couch> as sofa, as whole-language advocates suggest that parents and teachers should do, isn't a good way to promote the understanding that specific units of writing stand for specific units of language.

### 6.3 Theories

Most of the theories of spelling development that were discussed in chapter 4 give little consideration to how children learn about the glottographic nature of writing and what ideas they have about its symbolic function before they do. Indeed, some of the theories implicitly assume that children come to the task of learning to write already equipped with the knowledge that writing stands for speech. Thus, current connectionist theories $(\$ 4 \cdot 5)$ are built to learn about the specific links between linguistic units and visual units that occur in a writing system but not about the existence of such links. Dual-route theory $(\$ 4.2)$ posits a nonlexical route, which involves links between sounds and letters, and developmental versions of this theory claim that young children rely heavily on the nonlexical route for spelling. However, dual-route theory doesn't address the question of how children learn that writing works by assigning visual shapes to units of language.

Phase theory $(\$ 4.4)$ describes children in the prealphabetic phase of literacy development as lacking the knowledge that the letters of an alphabetic writing system stand for phonemes. The theory doesn't take a clear stand on whether these children know that writing represents language but have difficulty accessing the level of phonemes, or whether these children don't yet know that writing represents language at all. Constructivist theorists (\$4.3) also haven't taken a clear stand on this issue either with regard to children in the first or presyllabic stage of spelling development.

According to IMP $(\$ 4.6)$, even the most basic concepts about writingincluding the fact that writing stands for something outside itself, languagemust be learned at some point. The results we have reviewed in this chapter suggest that children in modern literate societies learn rather quickly that language stands for something outside itself. However, it takes several years beyond this for children to learn that writing stands for language. This delay reflects the difficulty of treating language as an object that can be inspected and thought about and represented in another form. The delay between learning that writing symbolizes something outside itself and learning that it symbolizes language is consistent with IMP's idea that learning about orthography involves knowledge about language as well as general-purpose cognitive skills. Limitations in a child's knowledge about language-in this case, knowledge that language can be treated as an object-can constrain literacy development. Children can start using their statistical learning skills to learn about the
visual characteristics of writing before they know that writing stands for anything, but they can't use their statistical learning skills to learn about the links between units of writing and units of language until they know that writing is glottographic. This means that children may learn a good deal about writing's outer form before they have much, if any, idea about how writing functions to represent language.

### 6.4 Conclusions

Learning that writing stands for something outside itself, namely language, is an important foundation stone for learning to spell. As we have seen in this chapter, it takes some time for children to learn that writing is glottographic. Although children know from an early age that writing stands for something outside itself, they don't know that it stands for language or how it does so. Children may instead think that writing connects to its object through spatial or temporal contiguity, as when «CREST〉 symbolizes 'toothpaste' because it appears on a tube of toothpaste. We have discussed children's early experiences with writing in terms of how they may help or hinder the understanding that writing represents language. For example, talk about written forms as being associated with people may not be very helpful in learning that writing represents language. Talk about written forms as being associated with function words may help in this learning, as may stress on exactness in reporting the meaning of writing.

One early experience that we have only briefly touched on so far involves learning about the letters of an alphabet in order, as through singing or recitation. In the United States and some other countries, such activities are quite common with young children. We discuss the order of the alphabetwhere it comes from, how children learn about it, and what they do with this knowledge-in the next chapter.

## CHAPTER 7 <br> The Order of the Alphabet

LEARNING AbOUT THE basic units of a writing system is an important founda－ tion stone for learning how the system works．We saw in chapter 5 that，at an early age，children in literate societies begin to learn about some of the formal properties of written words and texts．One of these properties is that writing is composed of separable units（ $\$ 5.2 \cdot 4$ ）．These units have shapes，names，and linguistic functions．For example，$\langle\mathrm{B}$＞is called／bi／in English，and it usually symbolizes the phoneme／b／．Of most importance for the present chapter， the units also have a conventional order．Thus，〈B＞comes after 〈A〉 and before〈C〉．In this chapter，we discuss why the order is the way it is，how children learn about the order，and how knowledge of this order affects their spelling． We focus primarily on the ordering of letters in alphabets，although we briefly consider other types of writing systems as well．In the chapters that follow，we take up other aspects of writing＇s basic elements：their shapes（chapter 8）and their names（chapter 9）．

Educators have sometimes assumed that children should become thor－ oughly familiar with all the units of writing，in their conventional order，before they start using these units to spell and read words．The idea that knowledge of the conventional order is a necessary foundation stone for learning to read and write has a long history．The ancient Greeks considered alphabet order so important that teachers apparently required their students to recite the alpha－ bet both forward and backward．In some cases，Greek children seem to have learned songs for this purpose．When children knew the letter names and their order by heart they began learning to associate each letter name with a graphic symbol（Mathews，1966）．A similar method，often called the ABC method，was popular in North America in the 1700 and 1800 s．

A belief in the importance of alphabet memorization remains ingrained in the United States and a number of other countries．Indeed，the first step in learning to read and write is often referred to as＂learning the ABCs．＂ In many countries，reciting or singing the letter names in order is among
children's earliest experiences with letters. Formal teaching about letters may start at the beginning of the alphabet and proceed straight through to the end. Children in phonics programs may spend one week studying each letter: the letter-of-the-week approach. These methods would be strongly justified if alphabet order followed some principle that children need to understand. But does it? We discuss that issue in the section that follows. We then review studies of how children learn about alphabet order and how that knowledge affects them.

### 7.1 Principles in Ordering

### 7.1.1 Arbitrary Ordering

In order to examine the considerations that underlie the ordering of letters, we begin by taking a quick look at the history of alphabets. This is useful because the vast majority of alphabets and alphabetical orders in use today stem from just a couple of systems. The Phoenician alphabet (see Table 7.1) dates back to the second millennium b.c. Due in large part to the immense economic and cultural influence of the Phoenicians, who were maritime traders from what is today Lebanon, the alphabet was borrowed for writing several other languages, including Aramaic and Greek. Aramaic, in turn, was borrowed for use with Hebrew and eventually Arabic. There is also some fragmentary evidence that Aramaic might be the ancestor of Brähmī, the mother of dozens of alphabets of south Asia. Greek, for its part, was the source of the Cyrillic alphabet widely used in eastern Europe and, via Etruscan, the Latin alphabet. Many of these scripts, especially Arabic, Cyrillic, and Latin, are today used for hundreds of different languages around the globe. Thus the Phoenician script was an immensely important source of the world's alphabetic writing systems. Table 7.1 shows an early form of the Phoenician script and three of its descendants. Each is in its own alphabetical order, but aligned so that letters in the same row all have the same historical origin. This arrangement necessitates some gaps to accommodate the occasional deletion, insertion, or relocation of letters in certain scripts. When letters are relocated or differentiate into two or more different letters, an arrow tells what row the letter originally came from. For example, in row 29 , the annotation on $\Omega$ shows that that letter is a version of Phoenician o that has been moved down from its original position in row 16. Parentheses around a Greek letter indicate that it was later dropped from the Greek alphabet.

The order of the Phoenician alphabet goes back to at least 1300 в.c., when an abecedary was written in Ugarit, a city in the north of Phoenicia. An abecedary is a listing of all the letters in an alphabet. That ancient abecedary was written in a different script, a version of cuneiform that looked nothing like Phoenician. But if the sounds of those letters are transliterated into Phoenician, skipping the sounds that don't occur in Phoenician, the result is the exact alphabetical order known from later Phoenician sources.

|  | phoenician | Greek | classical latin |  | MODERN | Latin |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | * | A |  | A |  | A |
| 2 | 4 | B |  | B |  | B |
| 3 | 1 | $\Gamma$ |  | C |  | C |
| 4 | 4 | $\Delta$ |  | D |  | D |
| 5 | \# | E |  | E |  | E |
| 6 | $Y$ | (F) |  | F |  | F |
| 7 | I | Z | ${ }^{3}$ | G |  | G |
| 8 | 日 | H |  | H |  | H |
| 9 | $\oplus$ | $\Theta$ |  |  |  |  |
| 10 | z | I |  | I |  | I |
|  |  |  |  |  | ${ }^{10} \mathrm{~L}$ | J |
| 11 | 4 | K |  | K |  | K |
| 12 | $\checkmark$ | $\Lambda$ |  | L |  | L |
| 13 | y | M |  | M |  | M |
| 14 | 4 | N |  | N |  | N |
| 15 | 夝 | $\Xi$ |  |  |  |  |
| 16 | $\bigcirc$ | O |  | O |  | O |
| 17 | , | п |  | P |  | P |
| 18 | $r$ |  |  |  |  |  |
| 19 | ¢ | (Q) |  | Q |  | Q |
| 20 | 4 | P |  | R |  | R |
| 21 | w | $\Sigma$ |  | S |  | S |
| 22 | $\times$ | T |  | T |  | T |
| 23 |  |  |  |  | ${ }^{24} \Gamma$ | U |
| 24 |  | ${ }^{6} \mathrm{~L}$, Y |  | V |  | V |
| 25 |  |  |  |  | ${ }^{24} \mathrm{~L}$ | W |
| 26 |  | $\Phi$ |  |  |  |  |
| 27 |  | X |  | X |  | X |
| 28 |  | $\Psi$ |  |  |  |  |
| 29 |  | ${ }^{16}$ L $\quad \Omega$ |  |  |  |  |
| 30 |  |  | ${ }^{24}{ }^{\text {L }}$ | Y |  | Y |
| 31 |  |  | ${ }^{7}$ | Z |  | Z |

People typically assume that there must be a good reason why alphabets have the order that they do, and many have gone to great lengths to find an explanation. The most exuberant effort to date may be that of Churchward (1931), who claimed that the names of the Greek letters, read off in alphabetical order, form a Mayan-language story about the sinking of a lost continent called Mu. However, scholars who are unwilling to hypothesize extra continents haven't succeeded in finding any credible organizing principle. A glance
at Table 7.1 reveals that the characters aren't arranged by shape. There are tantalizing indications that some of the letters might be grouped by similarity in their sound values. In Phoenician, the letters standing for voiced plosives are all grouped together (rows 2 to 4 in the table) and the two nasal consonants are grouped together (rows 13 and 14). But those patterns are meager, and their significance is called into question by the fact that the earlier Ugaritic abecedary had additional sounds that broke up those sequences. Perhaps the order follows some principle that no one has been able to figure out, or perhaps the order was essentially arbitrary from the start. Certainly, the alphabetical order in most Western scripts today is purely conventional, having no better explanation than that it was inherited from Phoenician.

As Table 7.1 suggests, most descendants of the Phoenician script have preserved its alphabetical order with surprising fidelity. Indeed, Hebrew (not shown in the table) retains exactly the same order with no additions, deletions, or relocations at all. The striking conservatism of letter order is one instance of the conservatism that people often show with regard to things they know and value. People treat the alphabet in much the same way that they sometimes treat a prayer or a pledge-as a text that is recited word for word in order to memorize it. Just as Christian children may learn to recite the Lord's Prayer before they understand what it means, so children often learn to recite the alphabet before they understand how letters are used to write words. Just as parents may correct a child who says a word of a prayer incorrectly or out of order, so they may correct a child's errors in reciting the alphabet. With both the prayer and the alphabet, a reverence for the received text leads people to believe that the exact ordering of the elements is important. The conservatism of alphabetical order is fostered by the fact that people work hard to learn arbitrary facts and sequences. Once people have learned something, they often begin to think that it couldn't have been any other way. People come to believe that alphabetical ordering isn't just a device by which they learned about their writing system but a property that is critical for its functioning.

### 7.1.2 Principled Ordering

Even though the descendants of the Phoenician alphabet have no discernible principles for ordering the alphabet as a whole, specific principles have almost always been applied when changes were made to the alphabet. These principles have some implications for children's learning, and we describe them in the sections that follow.

### 7.1.2.1 Deletions

When a language has no need for a particular letter, sometimes it is simply dropped from the alphabet. For example, the Greek alphabet had two [t] sounds, an aspirated one (Table 7.1, row 9) and an unaspirated one (row 22). Latin didn't have an aspirated sound and so it dropped the former letter.

| Row | Greek | classical cyrillic |  |  | v russian |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | A | ${ }^{2} \upharpoonright$ | A |  | A |
|  |  |  | Б |  | Б |
| 2 | B |  | B |  | B |
| 3 | Г |  | $\Gamma$ |  | Г |
| 4 | $\Delta$ |  | д |  | д |
| 5 | E |  | E |  | E |
|  |  |  | Ж |  | ж |
|  |  |  | S |  |  |
| 7 | Z |  | 3 |  | 3 |
| 8 | H |  | И |  | И |
|  |  |  |  | ${ }^{8}$ | Й |
| 9 | $\Theta$ |  |  |  |  |
| 10 | I |  | I |  |  |
| 11 | K |  | К |  | К |
| 12 | $\Lambda$ |  | л |  | л |
| 13 | M |  | M |  | M |
| 14 | N |  | H |  | H |
| 15 | $\Xi$ |  |  |  |  |
| 16 | O |  | O |  | O |
| 17 | П |  | $\Pi$ |  | П |
| 20 | P |  | P |  | P |
| 21 | $\Sigma$ |  | C |  | C |
| 22 | T |  | T |  | T |
| 24 | Y | ${ }^{16+24} \mathrm{~L}$ |  |  |  |
|  |  |  | Oy |  | y |
| 26 | $\Phi$ |  | $\Phi$ |  | $\Phi$ |
| 27 | X |  | X |  | X |
| 28 | $\Psi$ |  |  |  |  |
| 29 | $\Omega$ |  | $\Omega$ |  |  |
| 32 |  |  | Ц |  | Ц |
| 33 |  |  | ч |  | ч |
| 34 |  |  | Ш |  | Ш |
| 35 |  |  | Щ |  | Щ |
| 36 |  |  | ъ |  | b |
| 37 |  |  | ы |  | Ы |
| 38 |  |  | b |  | b |
| 39 |  |  | ¢ |  |  |
| 40 |  | ${ }^{10+1}$ L | H |  |  |
| 41 |  | ${ }^{10+5}{ }^{\text {L }}$ | € | ${ }^{5}$ | $\ni$ |
| 42 |  | ${ }^{10+16} \mathrm{~L}$ | ю |  | Ю |
| 43 |  |  | A |  | я |
| 44 |  |  | \% |  |  |
| 45 |  |  | HA |  |  |
| 46 |  |  | \% |  |  |
| 47 |  |  | 3 |  |  |
| 48 |  | ${ }^{28} \square^{\square}$ | $\Psi$ |  |  |
| 49 |  | ${ }^{\text {L }}$ | $\Theta$ |  |  |
| 50 |  | ${ }^{24}{ }^{\text {L }}$ | V |  |  |

But letters are often retained for a surprisingly long time，even when the sound they represent isn＇t needed for the language in question．The Phoenician alphabet had letters for two phonemes，／k／（Table 7．1，row 11）and／q／（row 19）， which to Greeks sounded like versions of the same sound．Greek kept both of them for several centuries even though only one letter was needed．Although the second letter，«Q»，was eventually dropped from Greek，it was retained long enough to find its way into the Latin script．It is still present in English as the letter «Q»，which has the same sound as 〈K»：compare «queen»／kwin／and〈keen»／kin／．

One motivation for retaining letters has been the tradition of using them as numbers．The first letter of the alphabet was used for writing 1 ，the sec－ ond for 2 ，and so forth through 9 ；the next 9 letters represented the decades， 10 through 90；subsequent letters represented centuries．Under this system， the Phoenician ancestor of 〈Q〉（Table 7．1，row 19）represented 90 in Greek． Dropping the letter entirely would have thrown off the link between numerical value and alphabetical order for 90 and all higher numbers．

The more general reason for retaining letters is conservatism and an aware－ ness that the alphabet is part of a cultural tradition shared with speakers of other languages．The letter $\langle\mathrm{K}\rangle$ is extremely rare in Spanish，being used only for some loanwords such as kilo，but children are typically taught it as a letter of the Spanish alphabet，where it retains its original position．When the Arabic alphabet is adapted for other languages，letters for distinctively Arabic sounds are still considered part of the alphabet，because they are felt to be necessary for the proper spelling of words essential to Arabic and Muslim culture．

## 7．1．2．2 Insertions

When new letters are added to the alphabet，they are most often appended at the end．The Latin alphabet，for example，originally ended with $\langle\mathrm{X}\rangle$ ．When the Greek letters 〈Y〉 and 〈Z〉 were borrowed to help write Greek loanwords， they were put at the end of the alphabet（Table 7．1，rows 30 and 31）．Danish placed its new letters $\langle Æ\rangle,\langle\varnothing\rangle$ ，and $\langle\AA\rangle$ at the end of the Latin alphabet，after〈Z〉．Table 7．2 illustrates the massive application of this principle in the evolu－ tion of the Cyrillic alphabet，which is used to write Russian and several other languages of eastern Europe and the former Soviet Union．Cyrillic is based on Greek，and is indeed very similar to it up through row 29 （the row numbers in this table are reprised from Table 7．1）．The early Cyrillic alphabet added 16 letters to the end of the Greek alphabet（rows 32 through 47）to spell Slavic sounds not found in Greek．In addition，Cyrillic relocated to the very end 3 let－ ters used for Greek loanwords（rows 48 to 50 ）．This technique of adding letters at the end does the least damage to the received text．We know of no cases in which a letter has been added to the beginning of the sequence，which would be perceived as more disruptive．

The other common tactic is to place new letters next to letters from which they are derived．This is readily discernible when the new letter is an elabo－ ration of the shape of the original letter，perhaps through the addition of a
diacritic mark．For example，〈J〉 was derived from 〈I〉 and was placed after it（Table 7．1，row 10），and 〈W〉 was placed after 〈V〉．In Spanish，〈 $\overline{\mathrm{N}}\rangle$ follows〈 N »，and in Russian，〈Й〉 follows 〈И〉（Table 7．2，row 8）．Not rarely，a digraphic phonogram is treated as if it is a separate letter，in which case it is typically assigned an alphabetic position after the first letter from which it was derived． For example，in Albanian，«DH»，pronounced／$\delta /$ ，is considered a separate letter，which comes between «D＞and «E»，so that dhe＇earth＇appears in the dictionary after $d y$＇two＇．Inserting new letters before the original letter is less common，but it happens：Maltese places «Gं before 〈G〉．

In other cases a new letter is appended next to the letter it most resembles phonetically rather than visually．For example，the 〈CH〉 of Czech and Slovak， which is treated as a single letter and which stands for the voiceless velar con－ sonant $/ \mathrm{x} /$ ，comes after $\langle\mathrm{H}\rangle$ ，which sometimes has the same pronunciation． Cyrillic 〈Ж＞／3／was added before 〈3＞，which stands for the similar－sounding $/ \mathrm{z} /$ ．When the letter $Э$ was added to the Russian alphabet，it took the position formerly occupied by the phonetically similar $\mathfrak{I}$ ．

It is difficult to give universal principles that will predict whether a digraph or a letter with a diacritic is treated as a unitary letter and inserted into the alphabetical order．Digraphs seem less likely than diacritically marked letters to be treated as distinct letters of the alphabet，perhaps because there is no explicit visual clue telling the reader to when to treat a sequence of two letters as a single letter．For example，one reason not to treat «TH〉 as a single letter in English is because it looks exactly the same as the letter 〈T〉 followed by the letter 〈H〉．There is no such difficulty with diacritics，which can never be independent letters．For such reasons，the Royal Spanish Academy recently decided to stop treating＜CH〉 and «LL» as separate letters of the alphabet，but it still recognizes 〈 $\widetilde{\mathrm{N}}\rangle$ as being a differ－ ent letter from «N»（Real Academia Española，2010）．

Although diacritics that are used to express a different manner or place of articulation sometimes make a single letter with the base symbol and are included in the alphabet，those that express tone or stress rarely if ever do so． Vietnamese is a good example．In this system «a＞／a：／，«ă＞／a／，and «â＞／ə／cor－ respond to three separate phonemes and are considered three separate letters． But «á＞，where the diacritic is used to express high，rising tone，isn＇t considered a separate letter from 〈a〉．The same is true for other tone marks，as in «à and ＜ã＞．The different treatment of tone is consistent with the idea that tone is suprasegmental，not an inherent part of the vowel on which it is heard．

## 7．1．2．3 Reordering

Changing the order of letters in an alphabet is less common than inserting or deleting letters．But when it happens，it can provide even stronger evidence that people feel that letters belong next to letters that are visually or phoneti－ cally similar．For example，Kabardian uses Cyrillic letters，but «Э〉 has been moved from near the end of the alphabet to close to the beginning，just after ＜A＞，which represents a very similar vowel sound．

Arabic provides a striking example of changes in order to reflect similarity. The original alphabetical order was identical to that of Phoenician (Table 7.1), with six letters added at the end for representing Arabic sounds not found in Phoenician. The modern order is shown in Table 7.3. Whenever letters have a similar shape, they are now grouped together. This is true regardless of the original Phoenician ordering, which is indicated in the first column of the table. For example, the letters that are now in positions 3 and 4 (as shown in the last column) have been moved up to follow letter 2 because they have the same base shape, disregarding the dots. The fact that letter 10 was moved up from position 20 in Phoenician shows that letters were sometimes repositioned to follow letters whose base shapes are similar but not identical. It also appears that some letters may have been grouped together based on similarity of sound. For example, the arrangement groups together the letters for all four of the language's sibilant fricatives (letters 11 through 14) and all five of the language's pharyngeal or pharyngealized consonants (letters 14 through 18).

The scripts of southern Asia are derived from the Brāhmī script, an abugida alphabet first attested in the third century в.c. If, as is plausible, the Brāhmī alphabet was derived from Aramaic and hence ultimately from Phoenician, it has been reordered even more dramatically than has the Arabic alphabet. It is ordered first by manner of articulation: vowels, followed by diphthongs, then stops (plosives or nasals), then approximants, then fricatives. Within each of those groups, the letters are arranged by place of articulation, then voicing, nasality, aspiration, and length, all in a perfectly regular and phonetically accurate fashion.

Thus the organizing principle for the south Asian scripts is phonetic similarity, while that of the Arabic reorganization is mostly visual similarity but with probable phonetic components. Taken together, the reorganization of the Arabic and the Brāhmī orders provides additional evidence that people find it natural for an alphabet order to group together letters that have some degree of similarity, whether it be between their shapes or between the sounds that they symbolize. Nevertheless, a strong conservative tendency in treating received texts has prevented most of the writing systems descended from Phoenician from having a principled ordering.

### 7.1.2.4 Other Scripts

So far, we have been focusing on the principles, or lack thereof, that underlie the order of alphabets derived from Phoenician. In this section, we consider other scripts, including some that aren't alphabetic. While children's learning of the element ordering in most of the scripts discussed in this section hasn't yet been investigated, an understanding of a broad range of writing systems provides a helpful foundation for studies of children's learning.

In the ogham alphabet, which was originally used to write Irish, letters have the form of tally marks. There are four families of letters, each with five members. Within each family, each letter has from one to five lines. The number of such lines is a natural way to order letters within each family.
table 7.3 Arabic Alphabetical Order

| PHOENICIAN ORDER | ARABIC |  |  |
| :---: | :---: | :---: | :---: |
|  | SHAPE | PRONUNCIATION | ORDER |
| 1 | 1 | /1/ | 1 |
| 2 | ب | /b/ | 2 |
| 22 | $\because$ | /t/ | 3 |
|  | $\star$ | /日/ | 4 |
| 3 | ج | /d ${ }^{3} /$ | 5 |
| 8 | $\tau$ | /h/ | 6 |
|  | $\dot{\text { خ }}$ | /x/ | 7 |
| 4 | د | /d/ | 8 |
|  | ذ | /ठ/ | 9 |
| 20 | J | /r/ | 10 |
| 7 | j | /z/ | 11 |
| 21 | س | /s/ | 12 |
|  | ش | / $5 /$ | 13 |
| 18 | ص | $/ \mathrm{s}^{\mathrm{s}} /$ | 14 |
|  | ض | $/ \mathrm{d}^{\text { }}$ / | 15 |
| 9 | b | $/ \mathrm{t}^{\mathrm{s}} /$ | 16 |
|  | ظ | $/ \delta^{¢} /$ | 17 |
| 16 | $\varepsilon$ | /¢/ | 18 |
|  | $\dot{\varepsilon}$ | /8/ | 19 |
| 17 | ف | /f/ | 20 |
| 19 | ق | /q/ | 21 |
| 11 | $\checkmark$ | /k/ | 22 |
| 12 | J | /l/ | 23 |
| 13 | - | /m/ | 24 |
| 14 | ن | /n/ | 25 |
| 5 | - | /h/ | 26 |
| 6 | و | /w/ | 27 |
| 10 | ي | /j/ | 28 |



Graphic similarity also plays a major role in the ordering of Arabic letters, as mentioned earlier. For most writing systems, however, it is unclear how two or three dozen basic elements, differentiated so as to be both simple to write and yet easy to tell apart, can be grouped on the basis of graphic similarity. Most sets of letter shapes are less visually systematic than those of ogham, and
few writing systems use an ordering principle based on graphic similarity in a thoroughgoing way.

The phonetic ordering method described for the Brāhmī-derived scripts has been applied to some other unrelated scripts of Asia. The modern order of the Japanese syllabary (Table 2.2) is almost exactly that of the Brāhmī-derived scripts. Although these systems have a phonetically motivated ordering, that motivation isn't explicitly pointed out to learners.

A few scripts have been ordered by arranging them so as to form a pangram, a text that uses each of the characters only once. For example, the Javanese script, which was used to write a language of Indonesia, was an abugida alphabet based ultimately on Brāhmī. Its letters were arranged to form a poem that translates as

There were emissaries.
They had a dispute.
They were equally strong.
Here are the corpses.
The order that the letters appeared in that poem was used as the alphabetical order. Japanese syllabaries also used to be arranged by a pangram.

When alphabet ordering is phonetically rationalized, vowel versus consonant is almost always the first cut, probably because this is the most obvious and important distinction among phonemes. When new alphabets have been proposed as a replacement for the Latin alphabet, they usually order the symbols in a way that respects at least the consonant-vowel division. For example, the Deseret alphabet, which was developed in 19th-century Utah as a purely phonemic writing system for English and other languages, has a rational order where the vowels come first, and the consonants are arranged by manner and place of articulation, then by voicing. Even Korean hangeul, which abandoned its original Brāhmī-based ordering in favor of one based more on visual similarity, still separates the vowels from the consonants.

The symbols of syllabaries ( $\$ 2.2 .2 .2$ ) tend to be conceptualized as a table, with the initial consonants of the syllables listed in one dimension and the vowels in the other dimension. The order is then derived by reading the table by either rows or columns. In other words, syllabograms are grouped by their onset consonant sound and subarranged by a specified order for the vowels. Examples include Cherokee and Yi. For a Japanese syllabary, when a table is presented in textbooks for children, the symbols in each row may all be printed in the same color. Children are taught to recite the table column by column from top to bottom and right to left, and dictionaries respect that order. Japanese children aren't taught the rationale for the ordering, however.

Chinese has ways of ordering characters, the most traditional being based on the presence of subcomponents called radicals and by the number of strokes. Chinese children don't memorize the order and don't learn characters according to it, though. Memorizing in order a list of thousands of characters,
some of which are pronounced alike, would be quite difficult, and it must be patent that little would be gained by having children do this.

It is useful for the elements of a set to have a conventional order. Having an order serves an inventory function, making sure that all the elements are covered. The order can be used for indexing purposes, as in dictionaries. Any order would fulfill these purposes, though, as long as it is the same for everyone. The order doesn't need to have a principled rationale, and we have seen that in modern Western writing systems it usually doesn't.

### 7.2 When and How Children Learn About Alphabet Order

In a number of countries, children learn about the conventional order of their writing system's symbols from an early age. We discuss what children know and when and how they learn it in this section. Our discussion focuses on learners of the Latin alphabet and related scripts because most of the available information comes from learners of these systems.

### 7.2.1 Oral Methods

One way of learning about the order of letters is oral: Children hear others say letters' names in alphabetical order or put them in a song, and they learn to do these things themselves. It may seem odd to learn about writing in an oral fashion. However, oral recitation and singing are time-honored mnemonic tools, ones that are especially useful for remembering sequences that are truly arbitrary or that seem arbitrary to learners. Before writing was invented, and before it was widely used, sages, storytellers, and ordinary people often relied on rime and rhythm to help preserve information. Even today, people use rimes and song to help remember things that seem arbitrary to them, such as the number of days in months: "Thirty days hath September, April, June, and November...." Oral memory and chanting allowed generations of US schoolchildren to recite the Pledge of Allegiance to the national flag each morning, even if some thought that it said "I fed the pigeons to the flag" instead of "I pledge allegiance to the flag."

Oral methods are well suited to remembering letters' names in order because the names sound quite similar to one another in most languages, as we discuss in more detail in chapter 9 . People usually have difficulty recalling lists of similar-sounding items in order. When letter names are put into a chant, or when they are set to music, similar names become a help rather than a hindrance. However, information may not be processed deeply when it is presented in songs and verse. In one study, 4-year-olds who heard stories in verse didn't remember the content as well as those who heard the same information in prose (D. S. Hayes, Chemelski, \& Palmer, 1982). People enjoy verse and songs, but they sometimes pay more attention to the rhythm and the melody than to the words and their meanings.

Oral methods for remembering long and arbitrary lists often involve dividing the list into smaller and more manageable parts, or chunks $(\mathbb{\$} 3.1)$. Recall of an ordered list that isn't divided into chunks shows a primacy effect and a recency effect ( $\$ 4.1$ ) for the list as a whole: good performance on the first and last items. Recall of a list that is divided into chunks shows, in addition, a small primacy and recency effect for each chunk (Hitch, Burgess, Towse, \& Culpin, 1996). When reproducing a sequence, people may pause only briefly between the items in a chunk. They may pause for a longer period of time before a new chunk (McLean \& Gregg, 1967; Reitman \& Rueter, 1980), reflecting the time that is necessary to plan it. Although chunking has many benefits, it may conceal internal structure. For example, a child who says /'عləmeno/ (LMNO) as a single chunk may not know that /'عləmeno/ consists of four separable letter names.

In the United States, the alphabet is often sung to the tune of "Ah, vous dirai-je, maman," a French folk song that was made famous by Mozart. The US Alphabet Song has spread to some other English-speaking countries. Canada, for example, has embraced the song, even though the song requires $\langle Z\rangle$ to have the letter name /zi/ because it is rimed with $\langle\mathrm{V}\rangle / \mathrm{vi} /$. The name / $\mathrm{zi} /$ is an Americanism, replacing traditional $/ \mathrm{zed} /$, and is often stigmatized outside of the United States.

From an early age, US and Canadian children have many opportunities to learn the order of the alphabet orally. Their parents may sing the Alphabet Song to them, even when they are infants (Bergeson \& Trehub, 1999), and they may watch television programs and play with toys that expose them to the song. Pairs of letters in alphabetical order are common in parents' everyday language input to young children, in one study constituting over half of the letter pairs uttered by parents of US 1 - to 2-year- olds (Robins et al., 2013). In many cases, the alphabet is sung or recited when no letters are visible (Robins et al., 2012), giving children the opportunity to learn the letters' names and order but not how the names link to the shapes. Such is the stress on early learning of the alphabet that encouraging toddlers to do so appears on lists of important features of homes and childcare settings, together with such things as providing a safe environment for children and not hitting them (Bradley, Caldwell, \& Corwyn, 2003).

Children from the US show some knowledge of the beginning of the alphabet sequence as early as 1 to 2 years of age, being more likely to utter A and B and B and C together than to use other pairs of letters (Robins et al., 2013). As children get older, they begin to produce other letters in alphabetic order as well. When directly asked to sing the Alphabet Song, US children between the ages of $21 / 2$ and $3^{1 / 2}$ can often sing at least part of it (Worden \& Boettcher, 1990). In one study, about half of the children in a group with a mean age of 3 years and 3 months produced perfect or near perfect versions of the Alphabet Song (Brenneman, 1996). In another study, about half of the children in a group with a mean age of 4 years and 8 months sang the Alphabet Song with no errors at all (Treiman, Tincoff, \& Richmond-Welty, 1997).

Learning the alphabet sequence through oral recitation and singing is in some ways similar to learning the counting sequence. Indeed, some toys for children teach both letters and numbers, including a computerized drum that loudly recites the alphabet when placed on one setting and that counts to 10 when placed on another setting. The fact that letters and numbers both occur in ordered lists that children are encouraged to memorize probably contributes to children's confusions between the two systems, above and beyond the other similarities between letters and numbers that were mentioned in $\mathbb{\int}$.1.

Although the ordering of letters and of numbers is similar in some ways, there is a major difference. The ordering of numbers reflects mathematical principles: There is a reason why 5 comes after 4 and why 6 comes after 5. Children first learn to count in a rote fashion, but they later come to understand the reasons for the order. The ordering of letters in the Latin alphabet isn’t principled: There is no linguistic reason why 〈Q> comes after «P>. Children who store the order in memory and later think about why it is what it is won't find a good reason.

Although early learning of letter names in alphabetic sequence is stressed in some English-speaking countries, it isn't stressed in all. In England, for example, early learning of letter names isn't emphasized. The television program Sesame Street, with its focus on the Alphabet Song and letter names, isn't widely available there.

In some non-English-speaking countries, children sing translations of the US song, in some cases with small variations. Other songs, such as Naomi Shemer's "Alef-Bet" song in Israel, include a word that starts with each letter. Still others include a story that is unrelated to the letters but that makes the song more interesting. In a number of countries, however, alphabet songs are less widespread than in the United States and are learned later. Young children in some countries, including Argentina, the Czech Republic, and Russia, don't usually know any alphabet songs at all. These differences reflect, in part, cultures' attitudes about literacy instruction. When people believe that children should learn about letters and reading at school and not from parents and preschool teachers, they don't stress alphabet songs with young children, even when songs exist. Other variations across cultures reflect the characteristics of the alphabet songs. In Thailand, for example, schoolchildren sing a song that includes the name of each of the 44 letters of the Thai alphabet and a word that starts with each one. This song is relatively long, however. We are told that children don't usually learn it at home, in part because their parents have often forgotten parts of it.

### 7.2.2 Alphabet Books

Children sometimes learn about the order of the alphabet from alphabet books. These books became popular several centuries ago in England, reflecting the traditional view that children must be able to recite the entire alphabet before
being allowed to learn to write and read words. In England, the United States, and some other countries, alphabet books are often among the first books that parents buy for their children. For example, almost all of the US middle- and upper-middle-class 4 -year-olds in one study had at least one alphabet book at home (Mason, 1980). So important are these books considered that they have been called the soldiers of literacy (Camp \& Tompkins, 1990).

Alphabet books are designed to teach the letters' names in their conventional order, as well as to teach the letters' shapes and sounds. In a typical alphabet book, each letter appears by itself, often on a separate page. It may be shown in large type, in bold, or in uppercase; it may be filled or colored. The letters are thus more attractive and attention-grabbing than the writing that typically appears in books. Many alphabet books show both the uppercase and lowercase form of each letter. In a typical alphabet book, an object whose name starts with each letter is also pictured. The picture is usually near the corresponding letter-on a facing page or elsewhere on the same page. The name of this keyword is often printed nearby. For example, an alphabet book may show «E» and «e» at the top left of a page, a color picture of an elephant in the middle of the page, and the word «elephant» at the bottom right. Other alphabet books have more than one keyword for each letter, such as both <elephant> and «egg> for «E». Typically, the keywords for a given letter are related to one another only in that both of their names begin with this letter. In some alphabet books, the letter shapes are integrated into the pictures of the keywords. For example, <Q> may form the body of a quail, with the head drawn in at the top. Such devices draw children's attention to the letters, but at the risk of altering their shapes or suggesting that letters link directly to creatures or objects. In other alphabet books, the shapes of the letters have nothing to do with the shapes of the keywords. For example, no attempt may be made to make an elephant look like $\langle E\rangle$. Many alphabet books contain no print other than the letters and the keywords and consequently no plot or characters. Only by considering the alphabet sequence can one explain why a picture of an elephant is on the page before a picture of a fan or why a goat and a girl appear on the same page. Other alphabet books contain more writing, such as stories that use the keywords or stories in which the letters of the alphabet serve as characters. For example, «T» may be discussed as a lonely person with outstretched arms who is waiting for telegrams. Elements that children can manipulate are included in some alphabet books. For example, children may be able to lift the vertical line of the letter $\langle\mathrm{L}\rangle$ to reveal a ladder. Although alphabet books vary from one another in a number of ways, the order of the letters is sacred. We have never seen an alphabet book designed for young children that presents the letters in anything but the standard 〈A> to 〈Z> order. Even young children can learn from this, coming to anticipate the $\langle\mathrm{P}\rangle$ page after the $\langle\mathrm{O}\rangle$ page after repeated readings.

As we saw in chapter 5, young children spend little time looking at the print in storybooks, and they and their parents spend little time talking about it. Children appear to spend more time looking at the print in alphabet books
than in typical storybooks (M. A. Evans, Saint-Aubin, \& Landry, 2009)— although they still look much less at the print than at the pictures-and parents appear to spend more time talking about the print (Bus \& van IJzendoorn, 1988; Stadler \& McEvoy, 2003). Alphabet books that contain no print other than the letters and keywords are most likely to encourage attention to print (Saint-Aubin \& Evans, 2009). In one study, $2^{1 / 2} 2$ - to 3 -year-olds who interacted with a simple alphabet book of this sort learned to recognize more letters than children who interacted with a more elaborate alphabet book that included manipulative features (Chiong \& DeLoache, 2013).

Although alphabet books draw children's attention to the symbols of writing, there is a tension between attention to the symbols' outer form and attention to the symbols' functions. The appearance of the letters in alphabet books may promote the idea that print is meant to be noticed for its own sake rather than for what it stands for. Colored or filled-in letters look less like typical letters and more like pictures. In addition, the visual devices that draw children's attention to the letters sometimes deform the letters' shapes. For example, one book that depicts «C> as a character shows it crumpled up on its side, its shape distorted, after it has fallen from a tree. Such personification may also promote the idea that writing symbolizes creatures and objects directly.

Alphabet books typically attempt to teach children about the soundsymbolizing function of letters by presenting a picture of an object whose name starts with each letter and often the printed form of the object's name. Many considerations go into the choice of these keywords, including artistry and conformity with a story. This means that the keywords may be less than optimal for teaching children about letters' sounds. For that purpose, a keyword should be short and begin with a vowel or a single consonant not in a cluster, as children most readily identify initial phonemes in these types of words (Jiménez González \& Haro García, 1995; Schreuder \& van Bon, 1989; Treiman \& Weatherston, 1992). An ideal keyword should also exemplify a letter's typical pronunciation. Some of the keywords in alphabet books deviate from these desiderata, including egg (this word is pronounced with /e/ rather than $/ \varepsilon /$ in some dialects of English), dinosaur (the length of this word makes the initial $/ \mathrm{d} /$ harder to isolate), tree (this word begins with a consonant cluster, and /t/ changes its pronunciation under the influence of the following consonant), and chimpanzee (this word doesn't begin with either /s/ or $/ \mathrm{k} /$, which are the typical pronunciations of $\langle\mathrm{c}\rangle)$. Further problems arise if the child doesn't know the label for a pictured keyword or uses a label other than the intended one. For example, one $3^{1 / 2}$-year-old identified the furry creature on the <O» page of an alphabet book as a mouse rather than as an opossum (Yaden, Smolkin, \& MacGillivray, 1993), which isn't conducive to learning about the sound of «o〉.

The page of an alphabet book that is devoted to a particular letter may include pictures of objects other than the keyword, and other words may appear in the text. Hearing words other than the keyword when the text is read, or seeing pictures of other objects, may cause children to associate the
letter with the wrong word. For example, the $3^{1 / 2}-$-year-old mentioned above was read an alphabet book that showed, on the $\langle\vee\rangle$ page, a vulture dressed in a tuxedo reclining on the right diagonal of a $\langle\mathrm{V}\rangle$ and looking at himself in a mirror hanging on the left diagonal of the $\langle\mathrm{V}\rangle$. The father said " $\langle\mathrm{V}\rangle$ is for...," waiting for the child to fill in vulture. The child said mirror instead, naming an object in the foreground of the picture that was more familiar to her (Yaden et al., 1993).

English speakers typically use the phrase "___ is for ___" to associate the letter with the keyword, as in " $<\mathrm{V}\rangle$ is for vulture." Even if the phrase isn’t written in the alphabet book itself, adults often use it when reading the book to a child. This wording is somewhat obscure to children, who may not understand this sense of the word for. It may even promote a wrong idea-that letters belong to animate beings or to objects. Such an idea may be further strengthened if the keywords are names of people, as they are in some alphabet books.

Hearing and saying letters in alphabetic order, singing the Alphabet Song, and reading alphabet books are some of the main ways in which children in the United States and other societies learn about the conventional order of the alphabet before formal literacy instruction begins. Children may get additional experience with alphabet order from other activities. For example, computer games sometimes present the letters of the alphabet in order, and Web sites recommend that parents do such things as cut out letters from magazines and help their children place the letters on a cookie sheet in alphabetical order.

### 7.2.3 Learning About Alphabet Order at School

Once formal instruction about letters and reading begins, alphabet order often continues to be a priority. A poster showing the letters of the alphabet in order may be placed at the front of a classroom. Children may be taught about the shapes, names, and sounds of the letters in the order of the letters' appearance in the alphabet. Teachers who give weekly spelling lists to their students may have students alphabetize the words as one study activity. Reciting the alphabet in order may be a part of remedial programs for children who are having difficulty learning to read and write (Vadasy, Sanders, \& Peyton, 2006), and tests of literacy skill may assess children's knowledge of letter order (Berninger \& Rutberg, 1992). The assumption is that knowledge of the alphabet is important in learning to read and write and that knowledge of the conventional order of letters in the alphabet is an important part of alphabet knowledge.

### 7.3 How Does Knowledge of Alphabet Order Influence Children?

In a number of countries, we have seen, children learn the elements of writing in a conventional order. How does this knowledge influence children? Is alphabet order important enough to merit the stress that is often placed on it?

Children＇s experience with alphabet order affects their performance in tasks that require them to label individual letters．Learning letters in a sequence involves forming associations between adjacent letters，and so children occa－ sionally mislabel a letter with the name of a letter that is adjacent to it in the alphabet．This can happen even when the two letters don＇t have similar shapes or similar names．For example，US 4－and 5 －year－olds occasionally call «F» by the name of 〈G〉（Treiman，Levin，\＆Kessler，2007）．Children probably associ－ ate these two letters because they have heard their names said or sung next to one another，because they appear on facing pages of alphabet books，and so on． Like these US children，Arabic－speaking children who have been taught the letters in alphabetical order sometimes confuse letters that are adjacent to one another in the alphabet but that don＇t look much alike．Arabic children who hadn＇t received such teaching made fewer errors that are based on adjacency in the alphabet（Levin，Saiegh－Haddad，Hende，\＆Ziv，2008）．

Children are also more familiar with the first few letters of the alphabet than the later ones（Robins et al．，2013；Treiman，Levin et al．，2007）．One rea－ son for this is that adults usually sing or say the alphabet from the beginning， not always finishing it．Even when an entire sequence is presented，the first few items are generally remembered better than the later ones：the primacy effect $(\$ 4.1)$ ．Another reason why children are especially familiar with the first few letters of the alphabet is that these letters are used in some languages to label the alphabet sequence itself．For example，the alphabet is called the ABCs in English and the alefbet in Hebrew，alef and bet being the Hebrew names of the first two letters．Children＇s special familiarity with the initial elements of the alphabet can cause them to mislabel other letters with these names．A U．S 4－or 5－year－old who doesn＇t know the name of a letter is more likely to call it ／e／or／bi／than to call it／o／or／es／（Treiman，Levin et al．，2007）．One US youngster＇s use of／ebisidii／to refer to ice cream（Reich，1986）may have a similar explanation．This child＇s parents tended to spell out words they didn＇t want the child to understand．Unable to spell ice cream，the child used the only letter names he knew－the ones at the beginning of the alphabet．

Children＇s early spellings are also influenced by their knowledge of the alphabet sequence．When 5 －year－olds include letters in a spelling that don＇t match any of the phonemes in the corresponding spoken word，these letters are more likely to be ones that appear early in the alphabet than ones that appear later（Treiman，Kessler，\＆Bourassa，2001）．In addition，young children sometimes include sequences of letters in alphabetical order in their spellings （Pollo，Kessler，\＆Treiman，2009）．That is，sequences such as 〈BC» and 〈FG〉 are more common than expected by chance．Consider the US 5 －year－old who writes 〈CRDEF〉 when asked to spell the made－up word／sib／．Her choice of an initial «C» reflects her knowledge of this letter＇s name，／si／，and her use of «D＞，〈 E ，and＜ F$\rangle$ after «C〉 reflects her knowledge of alphabetical ordering．Why she inserts $\langle\mathrm{R}\rangle$ is unclear．

The findings just reviewed show that children are influenced by their knowledge of the alphabet sequence when labeling letters and spelling words．

This isn’t beneficial when the order of the letters is arbitrary．Calling $\langle\mathrm{F}>$ by the name of $\langle G\rangle$ is incorrect，and using the letters 〈D»，«E»，and «F» sequentially in the spelling of a word is likely to be incorrect too．

There are some ways，however，in which learning letter names in order can help children．Hearing or seeing letters in a sequence may interest children in letters and may help children to learn that they belong to the same category．It may help children to learn that the syllables／e／，／bi／，and／si／belong together and that the shapes $\langle\mathrm{X}\rangle,\langle\mathrm{Y}\rangle$ ，and $\langle\mathrm{Z}\rangle$ do too．The fact that numbers rarely occur in these sequences（Robins et al．，2013）can help children to learn that they belong to a different category．These things may be especially useful given that parents don＇t often explicitly label letters with their category：Phrases such as＂the letter 〈G〉＂are rare among parents of US preschoolers（Robins et al．， 2013）．Learning about the category of letters and about what it does and doesn＇t contain is important in learning about writing，although any order would serve that purpose．

Knowing the conventional order of the letters is helpful when a child quickly scans an alphabet chart at the front of the classroom to find the « Q$\rangle$ and remind herself of its shape．Knowing the order also helps people to look up information in dictionaries or other alphabetically arranged lists，although this is less important now that people can type a word into a computer search tool and find information about it．But knowledge of alphabetical order remains an important part of many cultures，as when rows of seats in a theater are labeled with letters in alphabetical order or books are shelved alphabetically by the last name of the author．

Although learning the conventional order of the letters has some benefits， these benefits probably aren＇t sufficient to merit the stress that is placed on the conventional order of the alphabet with young children in the US and some other countries．There are surely better orders than the alphabetical one in which to teach letters－approaches that consider the letters＇frequencies， shapes，and sounds．Similarly，there are surely more effective ways to help children with spelling and reading difficulties than having them chant letter names in order．

A number of the theories of literacy development that were reviewed in chapter 4 ，including dual－route theory，phase theory，and constructivist theory， discuss the importance of alphabet knowledge．Those discussions could be taken to suggest that all aspects of alphabet knowledge are important，includ－ ing knowledge of letters＇names，shapes，and sounds and knowledge of letters＇ conventional order．In our view，however，knowledge about order is less impor－ tant than knowledge about names，shapes，and sounds．This is especially true when order is basically arbitrary，as it is in a number of writing systems．We thus question the idea that a good deal of stress should be placed on learning the conventional order of letters．

We also question the assumption that children should become familiar with all letters of their writing system before starting to use the letters to spell and read words．This assumption，which dates back at least to the ancient Greeks，
persists in many modern programs for teaching children to read and spell. An alternative approach is to first teach children about a small set of common and useful letters and teach them how to form words from these letters. Additional letters can then be introduced, the new letters being used with one another and the already known letters. Such an approach could help to show children that learning a list of letters isn't an end in itself, that letters are important because they make words.

### 7.4 Conclusions

Whether a 19th-century child is embroidering the letters in alphabetical order on a piece of fabric or a 21st-century child is singing the Alphabet Song along with a computer, the child is learning about the letters and their conventional order. We have seen that the conventional order is basically arbitrary in most Western scripts, and we have argued that parents and teachers sometimes put too much stress on learning it. Although learning the letters as a list draws children's attention to their existence and to the fact that they form a set, children need to learn much more about letters in order to use them effectively for spelling. In the two chapters that follow, we consider other aspects of letters: their shapes (chapter 8) and their names (chapter 9).

## chapter 8 Symbol Shapes

AS WE SAW IN $\int 7.2$, one of children's earliest literacy-related experiences may be learning the names of the letters as an ordered list. A US 4-year-old may know that $/ \mathrm{e} /, / \mathrm{bi} /$, and $/ \mathrm{si}$ / are the names of letters and that they are recited in this order, but the child may not yet know what the letters look like. Whether children become familiar with the names of certain symbols before learning about their visual forms, as with the child just mentioned, or whether they learn the visual forms first, learning about the symbols' shapes is an important aspect of learning about a writing system. Children must learn about the characteristics of the shapes themselves, and they must also learn how each shape connects to a unit of language.

In most writing systems, the connections between symbol shapes and units of language are largely arbitrary. There is no intrinsic connection between the sound /b/ and the shape «B>; indeed, this shape symbolizes /v/ in Russian and $/ \mathrm{j} \partial /$ in Cherokee. However, the shapes themselves aren't arbitrary or accidental. As we discuss in this chapter, a number of principles underlie their graphic forms. We consider these principles and the factors that have led to them in $\int 8.1$, as this material provides a foundation for understanding how children learn about the shapes. A discussion of the shapes of punctuation marks is saved for $\int_{12.1 .1 \text {. In later sections of the current chapter, we discuss }}$ how children learn and use the symbol shapes of their writing system ( $\mathbb{8} .2$ ) and the roles of formal and informal instruction in this process ( $\$ 8.4$ ). We discuss, too, those cases in which symbol shapes bear a nonarbitrary relationship to linguistic units, as when the constituents of a shape relate to phonetic features of the corresponding phoneme ( $\$ 8.3$ ).

Theories of orthographic knowledge and its development grant that knowledge of symbol shapes is an important foundation for writing. However, most of the theories have paid little attention to how this knowledge is acquired. IMP, the theory that guides this book $(\mathbb{\$} .6)$, sees the learning of symbols' graphic forms and the learning of connections between forms and functions
as guided by the same principles that guide other aspects of learning. In a final section of this chapter, we consider the findings about the learning of letter shapes in light of IMP.

### 8.1 Principles That Underlie Systems of Symbol Shapes

The symbols of writing may be viewed as graphic objects, independent of the fact that they symbolize language. In order to address the question of how children learn about these objects, we must examine their characteristics. The most fundamental characteristic of the symbols of modern writing is that they are linear, in the sense defined in $\mathbb{\$ 2 . 1 \text { . That is, they are composed of straight }}$ or curved lines in a two-dimensional space. In this section, we will see that the particular shapes are molded by a set of seven principles that hold true across scripts. We discuss these principles in the sections that follow. As we will see, some of the principles pertain mainly to the individual shapes. They help to explain why certain shapes, such as the Komi (northern Russia) letter in (1), are more likely to be elements of alphabetic writing than other shapes, such as the sunflower picture in (2). Other principles pertain to the symbols of a writing system as a set. They help to explain why one script contains the symbols in ( 3 , Hebrew characters) and another contains the symbols in (4, Kannaḍa characters), but why it is uncommon to find scripts whose symbol shapes embody an extreme mixture of different design principles, such as using characters in (3) alongside characters in (4).
(1) $\Omega$
(2)
(3) אבגדהוזחטיכלמנסעפצקרשת


### 8.1.1 Economy

One principle behind symbol shapes is economy. In writing, as in other areas, people tend to satisfice: to do the least they can in order to achieve a satisfactory result ( $(1.1)$. Writers, the focus of interest in this book, want shapes that they can produce quickly, with little cognitive and muscular effort, and in relatively little space. Readers, too, want shapes that they can perceive quickly and accurately. As writing is used more widely, considerations of economy become increasingly important.

Many modern symbol sets have been shaped by factors pertaining to ease of production with instruments such as pens and pencils, and we begin our discussion of economy with this method of production in mind. Several factors allow writers to achieve satisfactory results with a minimum amount of time and effort when using these instruments (Thomassen, Meulenbroek, \& Hoofs, 1992; Thomassen \& Tibosch, 1991). The number of segments that need to be produced is one consideration. Characters with few segments, such as 〈।>,
generally require less muscular and mental effort than characters with more segments，such as $\langle\mathrm{W}\rangle$ ．Continuity is another consideration．Difficulties can arise when the implement must be lifted above the writing surface，breaking continuity．When a character contains several identical parts，as with the hori－ zontal lines of 〈 F$\rangle$ ，it is usually most economical to produce them in succes－ sion，allowing reuse of the same motor program．

The considerations just discussed encourage the development of charac－ ters that contain few segments and connected segments．Across writing sys－ tems，it is estimated，characters average only about three segments（Changizi \＆Shimojo，2005）．The segments usually connect to one another．In Chinese， for example，characters like 四＇four＇，where all segments join，far outnumber characters like 三＇three＇，where no segments join．Indeed，when a sequence of two letters comes to stand for one sound，it isn＇t unusual for the letters to be connected so that they look like one．For example，it used to be common for printers to use «æ＞to show that the Latin «ae〉 diphthong in words like ＜encyclopædia» is pronounced as a simple vowel．Strokes that don＇t join to one another are usually at least close．Texts may provide other cues about which lines are meant to go together．Chinese characters are laid out in a square virtual grid，and this provides a strong clue that the lines in a character such as 三＇three＇belong together．The diacritics of such forms as «é＞are small and close to the base，perpendicular to the flow of text．This probably helps people to group the unconnected parts．

In handwriting，conventions develop about the order in which segments are produced and the directions in which they go．The order that becomes con－ ventional tends to be one that permits a satisfactory result with a minimum of time and effort．For example，Japanese ひ is most economically drawn by form－ ing the small segment on the top left from left to right，moving directly into the large semicircle，and finishing with the short segment on the right．Other possible orders，such as starting with the large semicircle and then forming the small lines at the top，require raising the writing implement in the middle of the character，which is less economical and more prone to error．When a lift of the writing instrument is necessary，writers can achieve more accurate results if they anchor a new segment from a point on an earlier－drawn segment than if they begin in empty space and join to an existing segment．Thus，people usually begin the horizontal line of $\langle\mathrm{L}\rangle$ by anchoring it on the existing vertical． Demands sometimes compete with one another．For example，producing the three parallel horizontals of $\langle\mathrm{E}\rangle$ consecutively allows reuse of the same motor program，a positive，but requires a lift of the pen，a negative．

Writing by hand is more efficient if the general sequence of strokes is simi－ lar from one character to another．This allows writers to gain fluency with the repeated patterns and gives them fewer decisions to make．These things are particularly important for a system like Chinese，in which characters may have many strokes．Thus，conventions develop about the direction and ordering of strokes．Economy becomes a property not only of individual symbols but also of the symbol set as a whole．

When forming Latin letters，writers often start at the top left，drawing vertical lines from top to bottom and then horizontal lines from left to right． Circular and semicircular forms are typically drawn counterclockwise．When a letter has a vertical line and a circular or semicircular form on the right，as does ＜b＞，writers typically make the vertical line first．When there is a circular form on the left，as with $\langle q\rangle$ ，writers may form that first．There is thus a left－to－right directionality in the formation of individual letters，consistent with the overall directionality of the script．Writers of Arabic，consistent with the right－to－left direction of their script，begin most of the letters on the right rather than the left．Writers of Chinese draw vertical strokes from top to bottom and horizontal strokes from left to right，as with the Latin script．Unlike in the Latin case，they typically form horizontal strokes before the vertical ones that cross them．The outside strokes of a Chinese character are generally formed before the inside ones，but one outside stroke is saved for last．Some of the patterns we have mentioned，such as the tendency to form vertical lines from top to bottom， characterize almost all scripts．Other patterns，such as the tendency to start at the left or the right，vary more across scripts．In all cases，though，writers ben－ efit from being able to use the same pattern in forming a variety of symbols．

A graphic component that appears in a number of symbols and that is formed the same way each time becomes a chunk（ $\mathbb{\$ 3}$ ．1）．Producing a graphic chunk in a standard way decreases the number of decisions that people must make and increases fluency with the sequence．For example，in Chinese writ－ ing，combining a horizontal stroke，a vertical stroke，and a hook produces ］， which is itself considered a stroke．This more complex stroke，in turn，recurs in many characters such as 羽 $\gamma \check{u}$＇feather＇，which itself recurs in several char－ acters such as 翌 $y i$＇next＇．

Over time，the symbols of a writing system may change to make them more economical．Typically，these changes begin with informal forms that are called cursive in the sense that they are flowing，quick，and nonmonumental． Angles may change to curves，and smaller segments may be omitted．Cursive forms may remain informal，or they may become accepted as standard forms． Japanese hiragana originated from Chinese characters that were significantly more complicated and required more lifts of the pen than their current，cur－ sive forms．For example，the three－stroke hiragana syllabogram む $m u$ derives from the eight－stroke logogram 武．Hebrew handwriting forms（5，second row） are another example of cursive，and some of them look quite different from the printed forms（first row）．
（5）ת ת ש


In Chinese systems，people have always tended to simplify characters when writing quickly for casual purposes．There are several styles of cursive writing， and in some of these the characters bear little resemblance to the form they
have in the regular script．For example，（6）shows＇turtle＇in traditional print form（first row）as well as in a highly stylized cursive calligraphy（second row； Character Gui Cur，2008）．Cursive simplifications are a large source of the simplified characters that became official，even for printing，in the People＇s Republic of China and Singapore in the latter part of the 20th century（ 7 ；sim－ plified characters are in second row，underneath their traditional forms）．
（6）龜
象
（7）書 車 東
书 车 东
＇book＇＇car＇＇east＇

Latin was originally written with one set of letters，those we now call upper－ case，or capital，letters．These tended to rounder and simpler forms when writ－ ten quickly with a pen，leading eventually to the lowercase forms in use today． For example，«B＞was simplified to the lowercase form 〈b〉．

Minimizing lifts of the writing instrument often results in styles that include ligatures between letters，where two or more letters are formed as a unit $(\mathbb{2} .4 \cdot 3)$ ．The Latin ampersand $<\& »$ originated as a quick way of writing $e t$ ，the Latin word for＇and＇．Medieval and early modern Greek regularly used dozens of ligatures，such as 〈8＞for «ou» and 〈ऽ〉 for $\langle\sigma \tau\rangle$ ．The desire to save space may also have contributed to the proliferation of such ligatures．

The need for speed and saving of space can lead ultimately to connected writing，where letters routinely are joined to each other．In Arabic，joining up of most letters is considered mandatory even in printing，as was illus－ trated in Example（2）in chapter 5．In other systems，such as Hebrew，joining of letters tends to be officially discouraged by educators but is common in quick handwriting．Some Chinese cursive styles join strokes that are nor－ mally unjoined．Other Chinese cursive styles even join individual characters to one another．

Shorthand systems are perhaps the most extreme example of systems that developed with economy－both economy of production and economy of space－as the primary consideration．Such systems were widely used by secretaries and journalists before the advent of such devices as tape recorders． The symbols of shorthand systems are generally simpler than the symbols of typical writing systems，and certain common words have special abbrevi－ ated forms．Shorthand is quick to write，but it can be difficult to read．People who take notes in shorthand usually transcribe them into normal writing soon afterwards，supplementing the notes with their memory of what they heard．

Within a script，common symbols tend to be simpler and smaller than less common symbols．For example，common Chinese characters tend to have fewer strokes than less common characters（Shu，Chen，Anderson，Wu，\＆ Xuan，2003）．The relatively low number of ascenders（as in «b〉）and descenders
(as in 〈g〉) in the lowercase vowel letters of the Latin and Cyrillic scripts may also be linked to the high frequency of these letters. Being written so often over time, these letters may have become compact. Simplification may occur over the lifetime of a person as well as over generations of people. For example, the signatures of people who have been signing their names for decades are often so abbreviated as to be difficult to read.

As the case of signatures shows, too much emphasis on economy can cause problems for readers. The trade-off between the writer's need for economy and the reader's need for symbols that clearly contrast-another principle that we discuss in more detail in $\int 8.1 .6$-will be familiar to those who have tried, and sometimes failed, to decipher doctors' handwritten prescriptions. It isn't surprising that the name of an unfamiliar drug would be difficult to read, but even an English phrase such as "take one at bedtime" may be illegible. The ambiguities that can arise from too much simplification guard against excessive application of the principle of economy. A further guard is the modifications that have developed in certain rapid styles. For example, the ascenders and descenders in some lowercase Latin letters help people to identify the letters, because they provide a strong element of contrast with letters that don't have them.

When a letter shape changes so as to fit better with the shapes of preceding or following letters, the letter is no longer written in the same way across words. Such variation is prominent in Arabic, where most letters have different forms depending on whether they are followed by another letter in the same word. For example, the letters for / $\mathrm{f} / \mathrm{and} / \mathrm{f} /$, which look very different when not connected to other letters, become very similar when connected to letters on both sides (8).
Sound
Not connected
Connected on both sides
Connected examples


Certain styles of connected cursive writing for the Latin script also prescribe changes as a function of the preceding or following letter. For example, the formation of the upstroke of $\langle k\rangle$ is influenced by the preceding letter: It will be long and more curved after a cursive $\langle a\rangle$ and shorter after a cursive $\langle 0\rangle$. At the beginning of a word, either shape is acceptable. Thus, a letter's shape is less variable when it is in the middle or at the end of a word than when it is at the beginning (Wing, Nimmo-Smith, \& Eldridge, 1983).

Variability in how a letter is formed may help experienced readers anticipate a following letter (Orliaguet, Kandel, \& Boë, 1997), just as an /m/-like pronunciation at the end of green may help experienced listeners anticipate that the next word might be bean, which begins with closed lips as $/ \mathrm{m} /$ does.

However，variant forms of a letter add complications for children who are learning to write．

Letter shapes may vary not only across contexts but also across writers． Especially with lowercase forms and connected writing，the same letter may look rather different when produced by different people．Experienced users of a system benefit from such variations to recognize people via their handwrit－ ing and to discern such things as whether a note was written slowly or in haste． But variations across writers increase the number of forms that children must learn for each letter．

The changes in symbol shapes that occur under the pressure for economy are typically driven by language users themselves，not by outside authorities． But deliberate reforms have sometimes been imposed．On the idea that many Chinese characters were difficult to write by hand，a thoroughgoing reform in the second half of the 20th century led to the graphic simplification of hun－ dreds of characters in the People＇s Republic of China and in Singapore．The characters in（9）include＇rain＇and phenomena related to rain，as they were written before（top row）and after the reform．Before the reform，all the related characters included the character for＇rain＇as their top component．After the reform，＇snow＇and＇thunder＇were left unchanged，retaining the＇rain＇compo－ nent，but＇electricity＇（i．e．＇lightning＇）and＇cloud＇were simplified，omitting the ＇rain＇component．The new characters are undeniably much quicker to write than the original ones．But the meanings of the two changed characters must be memorized by rote；there is no longer any clue that the morphemes they stand for have any connection to rain．In part for such reasons，some Chinese people advocate a return to the earlier，more complex characters．But by no means are all simplifications as dramatic as with these characters．

|  | Yǔ <br>  <br> ＇rain＇ | xuě <br> ＇snow＇ | léi | diàn | yún |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ＇thunder＇ | ＇electricity＇ | ＇cloud＇ |  |  |  |
| Traditional | 雨 | 雪 | 雷 | 電 | 雲 |
| Simplified | 雨 | 雪 | 雷 | 电 | 云 |

We have focused so far on writing with instruments such as pens，where symbols tend to evolve from larger and more angular to smaller，curved，and joined up，the latter being more economical to produce．But the specific forms that are economical to produce depend on the methods that are used to pro－ duce them．When carving on wood became important in a particular society， the shapes of the symbols sometimes changed to make that easier．For exam－ ple，the ancient futhark runes that were used to write Scandinavian languages turned all the curves of Latin into straight lines meeting at nonperpendicular angles，making the symbols easier to carve on wood（10）．


Nowadays, as children and adults spend more time writing with keyboards, ease of producing letters with pens and pencils is less important. Many of the reasons that were cited for simplifying Chinese characters disappear, for example, when people use computers. Economy is increasingly defined in terms of ease of keyboard use. The keyboard layout that is standard in English-speaking countries was developed because that arrangement of the keys minimized jamming on 19 th-century typewriters. Alternative designs might allow people to type more quickly and accurately. The keyboards that are standard in some other countries were developed with rapid and accurate production as a major consideration. The Russian layout, for instance, has the very frequent letters $\langle\mathrm{A}\rangle$ and $\langle\mathrm{O}\rangle$ under the home position of the index fingers, making them arguably the easiest letters to type. This is a more logical assignment than the English keyboard's, which puts the much less common letters $\langle\mathrm{F}\rangle$ and $\langle\mathrm{J}\rangle$ there.

If pressing a single key suffices to produce all letters, then complex letters are no harder to produce than simple letters. If the production of some letters requires more than one key to be pressed, however, then writers may avoid those letters. For example, the standard International Phonetic Alphabet $\langle\mathrm{g}\rangle$ is sometimes replaced with «g» because extra work is usually required to enter $\langle\mathrm{g}\rangle$. We prefer <g>, being sticklers, and on more than one occasion have had to plead with editors and typesetters to use it.

### 8.1.2 Conservatism

Conservatism is a major influence on the shapes of writing's symbols. People value the familiar and are reluctant to change things that they have made an effort to learn, and conservatism is often fostered in the case of writing by a reverence for certain historical texts. The conservatism of letter shapes may be seen in the fact that the symbols of many scripts have changed strikingly little over thousands of years. When a new symbol is needed, a writing system usually makes a small modification to an existing symbol, ensuring that the new symbol feels somewhat familiar. Less often, a writing system borrows a symbol from another writing system. Inventing new symbols from scratch is rare. Testifying to the force of conservatism, a borrowing language may even keep symbols from the lending language that it doesn't need. For example, Latin had no use for the letter 〈K», which had the same sound value as «C〉. But it was retained in the alphabet and is today considered part of the alphabet of descendant languages such as French, Portuguese, and Spanish, all of which still have no use for the letter except for spelling certain foreign words.

### 8.1.3 Beauty

People want the tools they use to be beautiful as well as functional, and so they decorate even practical, everyday objects. This applies to writing as well as to pots and pans, and indeed the aesthetic qualities of writing have been important throughout history. Egyptian hieroglyphic inscriptions are renowned for
the elegance of their pictorial characters, which were often painted in colors echoing nature. In the past 2,000 years or so, European alphabets have often been written with ornamental additions. Serifs ( $\$ 2.1$ ) were added to the ends of lines, especially on monuments and in very formal manuscripts. Medieval scribes often added elaborate decoration to their manuscripts, especially to the initial letter of the first word in major text sections. In some styles, they also made extremely long ascenders and descenders on their letters. Many of these decorative elements have survived to modern times. All styles of writing in the major European scripts continue the spirit of emphasizing the initial letters of important words by using special, uppercase, letterforms that are larger than regular letters. Serifs are still predominant in present-day book fonts. Many styles of handwriting from the eighteenth through the twentieth centuries placed great emphasis on elaborate forms for uppercase letters and on turning ascenders and descenders into attractive, looped forms. Only in recent decades have large numbers of people begun to question the wisdom of requiring all children to learn and use these decorative writing styles in the early years of primary education. In China and Japan, some of the most valued calligraphic styles emphasize beauty so much that legibility is lost, so that even calligraphy experts have difficulty reading them. Arabic calligraphy is often highly elaborated for decorative purposes, largely filling in Islamic cultures the role played by representational art in other cultures. But even simple everyday forms of writing come to seem beautiful once they are familiar, in line with research showing that familiarity often breeds liking (Bornstein, 1989; Reber, Schwarz, \& Winkielman, 2004).

A strong emphasis on beauty can cause some problems. If writers change symbols too much to make them attractive, they may find that their messages aren't easily understood by readers. Even when ornamental styles were standardized and taught in schools, people so often found one another's handwriting unreadable that the instruction "Please print" became ubiquitous whenever legibility was important. Also, different writing styles and fonts that develop for aesthetic reasons give children more variants to learn. Consider the differences among $\langle g\rangle,\langle g\rangle$, and $\langle g\rangle$. Complex and aesthetically pleasing symbols such as those of Egyptian hieroglyphics, which in many respects are similar to Egyptian representation art, may make it harder for young children to distinguish writing from drawing and to learn that writing's main value is as a symbol. In addition, artistic and intricate forms take longer to produce by hand than simple ones, detracting from economy. Few people nowadays learn to write serif letter forms, with their attractive but complex elaborations on the ends of lines, as in «E». People often read serif fonts, and they often set them as the default fonts on their word processors, but when they write by hand they produce forms like «E> that are closer to sans serif $\langle\mathrm{E}\rangle$ than to serif $\langle\mathrm{E}\rangle$. Still, the time that some adults spend devising new fonts for printing or the time that some children spend writing puffy letters or letters with the enclosed parts colored in suggests that the drive for beauty sometimes outweighs the drive for economy.

### 8.1.4 Expressiveness

The main goal of writing is to convey linguistic information. For the reasons we have been discussing, however, the shapes of symbols sometimes vary in ways that don't convey linguistic information. For example, $\langle\mathbf{B}\rangle$ and $\langle B\rangle$ look different but represent the same sound. People sometimes exploit such variability to signal the social group to which they belong or to express their individual tastes, just as musicians may vary for expressive purposes the lengths of notes that are nominally the same. Variations in letter shapes may become conventionalized so that they become a secondary channel for conveying social information, above and beyond the primary (linguistic) information that writing is meant to convey. For example, the US community in which one of us lives uses a black letter calligraphic style on its street signs, even though it is less familiar to modern eyes than many other styles (11). The signs for this city's major streets use a common sans serif font, but the black letter font on the smaller streets is intended to convey an impression of sophistication and adherence to tradition.

## (11) Wyyomw Terrace

As another example, cursive script fonts that make adjustments similar to those used in handwriting, where the form of one letter is affected by the letter next to it, are sometimes used to give a handwritten flavor in a digital age.

The value that people place on personal expression is shown by the fact that they sometimes pick a particular font for everything they write on a computer as an indicator of their personal style. For example, one of our colleagues is known for her preference for Comic Sans. Other people change fonts or styles within a text as a means of expression, for example emphasizing some words in an e-mail message by writing them in ALL UPPERCASE LETTERS. One of us stopped doing this after the recipient of a message complained about the screaming. Despite such problems, technology that allows users a choice of fonts and sizes has become increasingly popular because it permits more expression.

Certain fonts express certain feelings because of their intrinsic properties. The heavy lines of bold typefaces, experiments confirm, express force and strength (Kastl \& Child, 1968). The expressive quality of other fonts is based on prior knowledge, as when black letter fonts are used to show adherence to historical tradition. One Catholic university benefits from associations based on prior knowledge by using a <t> that looks like a Latin cross when writing its name in its logo. A more typical <t> is used in the word university, yielding

Handwriting is potentially more expressive than text produced from fonts. Modifications for personal expression are particularly common with signatures. For example, perky Nicki writes her name with stars over both «i>s. Her signature expresses her personality; it is more than a symbol to see through. Likewise, Brett's way of using a lowercase «b» in his name becomes a kind of personal expression. People take advantage of variations in the shape of handwritten forms even when they lack linguistic significance. For example, people in countries as diverse as Pakistan and the United States are correct about two-thirds of the time-better than the $50 \%$ that would be expected by chanceat judging a person's sex from their handwriting (Hamid \& Loewenthal, 1996; Hartley, 1991). Decorativeness and embellishment are in many modern societies cues that a writer is female, although in medieval times they were cues that the writer was male, a monk. Although variation provides useful information for readers, it complicates the task of learning to produce writing by giving children more forms to deal with.

### 8.1.5 Similarity

The symbols of a writing system follow some common design elements, giving them a degree of unity. For example, Chinese characters are similar to one another in that they are composed of straight lines and gentle curves, with no complete circles. The letters of the Latin script consist of circles, semicircles, and lines. A number of them may be analyzed as a more or less vertical stem with one or more other segments added to it. The added segments are more likely to be on the right of the stem, as with 〈b» and $\langle R\rangle$, which are called b-type letters, than on the left, as with the d-type letters «d» and <y>. The b-type letters appear to many users of the system to face toward the right, the direction in which the script flows. Hebrew letters tend to be formed in a block-like architecture, with a predominance of very similar horizontal and vertical lines. They have few distinctive curves and diagonals, as do Latin letters. When Hebrew letters have a vertical stem, it is more likely to be on the right, as with and , than on the left, consistent with the right-to-left directionality of Hebrew writing.

The similarities among the symbols of a writing system are partly due to two of the principles already discussed—beauty and economy. Similarities among a set of forms make the set aesthetically pleasing. Also, groups of segments that appear in a number of different symbols can serve as chunks in production and perception, promoting economy. The similarities among the symbols of a writing system also reflect the writing instruments that are used in particular cultures. For example, cuneiform symbols were incised on clay using a reed stylus trimmed to yield the characteristic wedge-shaped marks.

Similarities among the marks of writing can help children to recognize that the marks belong to a class and that they differ from other types of marks, such as musical notation. Children can use the design features of a novel form to determine the class to which it might belong. Perhaps (13), letters invented by
the Roman emperor Claudius，could be printed letters of the Latin alphabet， but probably not（14），letters invented by Dr．Seuss（1955）for children＇s（and parents＇）amusement．Children can also use their knowledge of the graphic similarities among the symbols of their writing system to compensate for limi－ tations in their memory for specific items．A child who remembers that $\langle\mathrm{u}\rangle$ is composed primarily of curved lines but who doesn＇t remember its exact shape might be able to infer，given the design principles of the Latin alphabet，that it＇s probably not Q ．
（13）つ』ト

In some writing systems，the visual characteristics of symbols are linked to their linguistic functions．For example，certain visual features of Japanese and Korean symbols correlate with certain phonetic features．We discuss this topic in $\S 8.3$ ．For now，our point is that there are advantages to be had even when the visual components are arbitrary，as they are in most writing systems．Consider the open curves in Latin letters such as 〈c〉，«e〉，and 〈G〉．These letters don’t form a class in terms of their linguistic functions；the first and third represent consonants，for example，whereas the second represents a vowel．Even so，the repetition of the curve across letters aids learners．The repeated shape contrib－ utes to the unity to the script and helps set off writing from other visual marks．

The more symbols a system has，the more visually complex they must be and the more benefit can be gained from chunks that are repeated across symbols．Consider logographies（ $\$ 2.2 .2 .1$ ），which have more symbols than phonographic writing systems．Chinese characters，even the simplified ones currently used in the People＇s Republic of China and Singapore，are on average more complex than the letters of typical alphabets．A number of graphic com－ ponents are shared across characters，however．These shared design elements are useful when they suggest particular meanings or pronunciations，as they often do in Chinese，but they are useful even when they don＇t．

When a writing system includes different subsets of symbols，such as the upper－and lowercase letters of the Latin alphabet，some design principles apply across subsets and others are specific to particular subsets．For example，one subset of Hebrew consists of five letterforms that occur at the ends of words． Four of these final letters have a descender：$\rceil,\rceil$ ，, ，and $\uparrow$ ．Such a descender appears in only one letter that isn＇t distinctively final，p．As another example， the uppercase letters of the Latin alphabet are more angular and more likely to be symmetrical than lowercase ones．Lowercase letters are more curved and more often asymmetrical．They may be short，and some have ascenders or descenders．Uppercase letters are all full height．To maintain this design prin－ ciple of uniformity in height，writers of some languages avoid diacritics when writing words in all uppercase letters．In Greek，people write «METPO» even though it is ambiguous between $\mu \varepsilon \tau \rho o ́ ~ ' m e t r o ' ~ a n d ~ \mu \varepsilon ́ \tau \rho o ~ ' m e t e r ', ~ p o t e n t i a l l y ~$ confusing readers．Likewise，writers of French often omit diacritics on upper－ case letters．Design principles tend to be shared within a font as well as within
a case．For example，some decorative fonts for the Latin alphabet have major variations in line thickness within letters，as with $\mathbf{M}, \mathbf{A}$ ，and $\mathbf{N}$ ，making the forms visually similar．

Testifying to the importance of graphic similarity，adaptations to increase similarity may occur as scripts evolve．For example，many Phoenician let－ ters，such as $\uparrow, \imath$,$\urcorner ，and 4$ ，had more or less vertical stems with appendages （Table 7．1）．When an appendage wasn＇t symmetrical，it was almost always on the left side，pointing into the direction of writing in this right－to－left script． Exceptionally，८／lamdu／，the letter representing／l／，had the appendage on the right．It might not be a coincidence that Arabic and Syriac，both of which retained the right－to－left direction of Phoenician，turned the letter around to face the same direction as the other letters：Arabic $J$ and Syriac $\rfloor$ ．

Although one writing system sometimes borrows symbols from another， the need for new letters to express new sounds is more often met by modify－ ing letters that already exist in the script．Graphic similarity to the other ele－ ments of the script is important in this process．Modifications may involve small changes to the shapes of letters．In the Latin script，for example，$\langle J\rangle$ is a modification of the classical $\langle\mathrm{I}\rangle$ and $\langle\mathrm{U}\rangle$ is a modification of the classical $\langle\mathrm{V}\rangle$ ．A second tactic is to combine two letters into one，making a ligature． Modern Danish，like Old English，has 〈æ〉，a combination of «a〉 and «e〉，and French combines «o〉 and «e〉 to make «œ»．A third avenue for making new symbols is to add a small mark to an existing character．For example，the different pronunciations for «e» in French are，in part，disambiguated by adding diacritical marks，so that «é＞represents／e／and «è＞represents $/ \varepsilon /$ ． When new symbols are based on old ones，it seems almost trivial to expect the new symbols to have similar design features as the symbols on which they are patterned．One would hardly expect a slight modification of $\langle\mathrm{V}\rangle$ to end up looking like an Egyptian hieroglyph．But in fact nontrivial constraints are often applied in order to make the new characters look like prior ones． Chinese characters formed from other characters fit into the same square space that all other characters do，even if the constituents＇shapes must be modified to make that work．Sometimes the characters are compressed in one direction to get them to fit，as in the way the＇rain＇character was com－ pressed vertically when it occurred as part of the more complex characters in（9）．As another example，the 木 mù＇tree＇character is compressed hori－ zontally when combined with the 人 rén＇person＇character to make the char－ acter 休 xī̄＇repose＇．Other characters routinely take somewhat different forms when used in composition，as happened to the 人 character in this example．〈J＞，which was＜I〉 with an added tail at the bottom，is usually now the same height as $<\mathrm{I}\rangle$ to conform to the previously mentioned principle that all uppercase Latin letters have the same height．

There are many similarities among the basic symbols of a script，but even more similarities among the variants of a given symbol．For example，$\langle t\rangle,\langle t\rangle$ ， and 〈 $\dagger\rangle$ share many perceptual features．This similarity encourages children to treat them alike，as they should for most purposes．

## 8．1． 6 Contrast

The shapes within a system should be easy to tell apart：They should contrast． Lack of contrast can lead to errors in perception，production，and memory． Although some similarity among the elements of a script helps writers and readers，too much similarity can hurt them by violating the need for contrast． This becomes particularly important as more people read often and as they expect to do so easily and rapidly．The distinction between the closed curve shape of «O» and the open curve shape of «C» is easy enough to perceive，remem－ ber，and produce．Distinguishing between two open curve shapes that differ only by a minuscule difference in the size of the opening would be harder，and one wouldn＇t expect that many writing systems would have two symbols that differ in only that respect．When writing becomes smaller，as it often does with the need for economy，distinctions must be large enough to maintain contrast． The need for contrast also means that most writing systems contain few or no pairs of symbols that differ by only rotation or reversal．Some such pairs exist， including $ل$ and $L$ in Cree（see 16），卜（a）and $\dagger(e o)$ in Korean，and «b＞and $<\mathrm{d}>$
 learn that the members of such pairs belong to different categories．

One tension in the evolution of writing systems is finding an appropriate balance between similarity and contrast．To achieve a middle ground，visual forms may change to increase contrast．In some early forms of the Latin alpha－ bet，$\langle\mathrm{R}>$ looked very much like $\langle\mathrm{P}\rangle$（compare the ancestor of $\langle\mathrm{R}\rangle$ ，Greek $\langle\mathrm{P}\rangle$ rho， which still looks like Latin 〈P＞），so a diagonal line was added to better distin－ guish the two letters．In medieval times，«i＞came to be written with a dot to better distinguish it from other letters that consisted largely of small vertical lines，such as 〈 n$\rangle,\langle\mathrm{m}\rangle$ ，and $\langle u\rangle$ ．This technique was used more generously in Arabic，where several letters had come to look so similar that dots were added to distinguish such letters as $ب \mathrm{H} / \mathrm{b} /$ and $\dot{\mathrm{L}} / \mathrm{n} /$ ．In modern times，people some－ times attempt to distinguish the uppercase letter $I$ and the numeral 1 from lowercase $l$ by adding exaggerated serifs to the letter or by emphasizing the hook at the top of the numeral（15）．But this last form may end up looking too much like the digit 7，so most Europeans add an additional horizontal line to this latter digit．The resulting form，unfortunately，is sometimes mistaken for a cursive $\langle\mathrm{F}\rangle$ ．
（15）letter I：$\quad \mathrm{I} \rightarrow \mathrm{I}$
one：$\quad \mathrm{I} \rightarrow 1$
seven：$\quad 7 \rightarrow \nrightarrow$
cursive $\mathrm{F}: \quad$＇

## 8．1．7 Redundancy

Many symbols in many writing systems are more complicated than they need to be．For example，〈A〉 has many features，including two diagonals meeting at the top，a crossbar，and an interior closed space．If a child
misremembered or misperceived one feature，the remaining features might still suffice to pinpoint the correct symbol．At the least，the remaining fea－ tures would serve to narrow down the choices．According to one estimate，in fact，the identity of symbols of modern writing systems can be determined when，on average，half of the segments are removed（Changizi \＆Shimojo， 2005）．Redundancy，in this sense of an item being more complicated than needed in order to achieve a goal，tends to increase the contrast among items in a set while maintaining some similarity among them．However， such redundancy detracts from economy．

The need for redundancy helps to explain why symbol shapes don＇t usually show a high degree of systematicity．A few writing systems are quite systematic from a graphic point of view，including Cree．This abugida alphabet，which was invented in the 1800 ，contains symbols that differ in orientation（16）and in the presence or absence of dots in certain locations（17）．These variations are systematically applied to a small number of basic shapes to indicate such things as the syllable＇s vowel．However，Cree lacks redundancy．A child who failed to perceive a single property of a single element of a symbol，such as the exact location of a dot or orientation of the basic shape，could easily mistake it for another．The symbols of most mature writing systems are less systematic than those of Cree，and people must attend to different features with different letters．For example，a child could ignore the horizontal line in 〈A〉；the letter is still recognizable if the line is deleted．But the horizontal line is critical with ＜G»；a different letter results if the line is missed．As another example，deleting the dot at the top of＜i＞yields a different letter with a different sound in Turkish， ＜1＞／w／，whereas deleting the dot at the top of $\langle j$ doesn＇t．
（16） $7 / \mathrm{me}: /, \Gamma / \mathrm{mi} /, ل / \mathrm{mo} /$ ，L／ma／
（17）$\Gamma / \mathrm{mi} /, \Gamma \cdot / \mathrm{mwi} /, \Gamma \cdot / \mathrm{mwi} /$
The symbols used in nonlinguistic methods of permanent communication and many of the trademarks used by corporations，including（18）and（19），are more complicated than symbols of writing．Their detail and complexity make them difficult and time－consuming to produce by hand．They typically take up more space than symbols of writing，for certain visual details would be lost if they were reduced too much．The symbols of writing were developed for ease of pro－ duction as well as ease of perception，and this has limited their visual complexity．

（19）


## 8．1．8 Summary of the Principles That Underlie Systems of Symbol Shapes

The symbols of different writing systems look rather different from one another．These differences are obvious when comparing 〈t＞，＜d＞，and＜z＞of the

Latin alphabet；$\because, ~ د$ ，and $j$ of Arabic，which represent the same phonemes； and 木＇tree＇，菜＇vegetables＇，and 我＇me＇of Chinese．Despite their differ－ ences in outer form，the symbols of all writing systems follow a set of under－ lying principles．The symbols in a system are similar to one another in their graphic qualities，yet reasonably easy to discriminate from one another．They are economical to produce and economical of space，and they have a degree of redundancy．The shapes are attractive and expressive，similar to those that have been used in the past．These principles apply whether a writing sys－ tem represents language at the level of phonemes，syllables，or morphemes． The principles we have discussed－similarity，contrast，economy，redun－ dancy，conservatism，beauty，and expressivity－sometimes compete with one another．For example，similarity can detract from contrast，redundancy can detract from economy，and expressiveness can detract from conservatism． Competition occurs，in part，because some of the principles primarily ben－ efit writers and others primarily benefit readers．For example，economy is particularly important for writers，and redundancy and contrast are particu－ larly important for readers．But writers are typically also readers，and writing systems must balance the needs of the two．The systems of symbol shapes in use today represent attempts to satisfy a number of different demands． They represent a middle ground between trademarks and logos，with their emphasis on ease of perception，and shorthand systems，with their emphasis on ease of production．

An understanding of the symbols of writing as graphic objects provides an important foundation for an understanding of how children learn to use the symbols．For example，the fact that the symbols of a writing system are visually similar to one another suggests that an important aspect of learn－ ing is learning about the graphic commonalities among the elements of a script．We discuss this and other aspects of learning in the section that follows．

## 8．2 Learning and Use of Shapes as Graphic Objects

Knowledge of symbol shapes isn＇t built in to children，for they must learn different shapes in different societies．In this section，we consider how they do so．Although our focus in this book is on how children learn to produce writing，we consider the recognition of shapes as well as the production of shapes in the discussion that follows．This is because accurate production of a letter is based on a mental model of the shape，one that often devel－ ops through perceptual experience．Our discussion of production focuses on the production of letters with implements such as pens and pencils－ the traditional method and the one with which children still most often begin—but we also consider typing，which is increasingly used by children and adults．

## 8．2．1 Learning About the Similarities Among the Shapes of Writing

One important part of learning about the shapes of a writing system is learn－ ing about their graphic similarities．Children in literate societies begin to learn this at an early age．Thus，as mentioned in $\$ 5.2 .4$ ，US 3 －and 4 －year－olds tend to reject as writing strings that are composed solely of Chinese characters， symbols from Indian writing systems，or other symbols that look rather differ－ ent from letters of the Latin alphabet（Ganapole，1987；Lavine，1977；Treiman， Cohen，Mulqueeny，Kessler，\＆Schechtman，2007）．Children of 3 and 4 years of age tend to accept as writing symbols that share the general visual properties of their writing system＇s symbols but that differ in the details．For example，a group of US children with a mean age of 3 years and 3 months（Brenneman， 1996）accepted strings of Cyrillic and Hebrew letters．The letters of these scripts look rather similar to Latin ones．Similarly，most of the children in a group with a mean age of 3 years and 7 months judged a display like $\langle\mathrm{f} \nabla \emptyset \mathrm{t}\rangle$ as＂something to read＂（Ganapole，1987）．The shapes in this display that aren＇t letters of the Latin alphabet don＇t look all that different from Latin letters．

Additional evidence that young children in literate societies are sensitive to the graphic similarities among their writing system＇s symbols comes from their own productions．Even when children＇s forms are unconventional，they may be similar in some ways to the written symbols in the children＇s environments． For example，as mentioned in $\$ 5.2 .6$ ，young children who have been exposed to Chinese tend to use angular forms in writing，avoiding the circles that rarely appear in Chinese characters（Chan \＆Louie，1992；Treiman \＆Yin，2011）．

Children learn shapes that are more typical of their writing system more readily than shapes that are less typical，and they sometimes modify atypi－ cal shapes to make them more typical．This happens with the Latin alphabet， which as mentioned earlier contains a number of letters with a more or less vertical stem and another form appended to it．The appendage is more often on the right，as with 〈b＞and 〈p＞（20），than on the left，as with 〈d＞and $\langle j\rangle(21)$ ． Four－to six－year－olds are better at copying b－type letters than d－type letters and better at printing them from memory（Treiman \＆Kessler，2011）．They are more likely to reverse a d－type letter，such as writing 〈b〉 for 〈d〉（22），than to reverse a b－type letter（23）（Fischer \＆Tazouti，2012；Treiman \＆Kessler，2011）．These results suggest that learners of the Latin alphabet apply their statistical learn－ ing skills to the letter shapes they see，learning that more letters have the b－type pattern than the d－type pattern．Children who remember that a letter has a stem and an appendage but who are unsure of the left－right position of the appendage use their knowledge about its typical position．
（20）b－type：B b DEFhKkLmnPpRr
（21）d－type：a d g J j qu
（22）More common reversals：$d \rightarrow b, J \rightarrow L$
（23）Less common reversals： $\mathrm{b} \rightarrow \mathrm{d}, \mathrm{L} \rightarrow$ ل

Further evidence that children learn about the graphic patterns that charac－ terize the shapes of their writing system comes from Chinese．Certain groups of strokes usually or always appear in some positions of a Chinese character， such as on the left side or the right side，and other groups appear in other posi－ tions．Chinese children show some knowledge of the patterns even when the patterns aren＇t explicitly taught at school（Anderson et al．，2013；Chan \＆Nunes， 1998；Luo，Chen，Deacon，Zhang，\＆Yin，2013）．When asked to copy made－up characters or characters they haven＇t learned at school，for example，6－year－olds tend to perform better on those in which a common group of strokes appears in a typical position than in an atypical position．Children perform even more poorly on made－up characters that contain groups of strokes that don＇t occur at all in Chinese．

A number of societies use the Latin alphabet together with the Hindu－Arabic numerals，two sets of symbols that look similar in many ways．Indeed，the let－ ter $\langle 1\rangle$ is very similar to the numeral $\langle 1\rangle$ ，to the point that manual typewriters sometimes provided only one symbol for both purposes．The letter 〈 O$\rangle$ is simi－ lar or identical to the numeral $\langle 0\rangle$ ，and $\langle\mathrm{S}\rangle$ is similar to $\langle 5\rangle$ ．However，the two sets of symbols differ in some of their design principles．Whereas the b－type pattern is more common than the d－type pattern among the letters，the digits are more likely to have the d－type pattern，as in 〈7〉 and 〈9〉，than the b－type pattern．Another difference is that some lowercase letters have ascenders and descenders，whereas no numerals do，except for the now unusual old－style numbers（24）．Moreover，numerals tend to be visually simpler than symbols of writing（Changizi \＆Shimojo，2005）．
（24）Old 0123456789
New 0123456789

Letters and numerals look rather similar to one another in some societies that use a writing system other than the Latin alphabet，a number system other than the Hindu－Arabic one，or both．Roman numerals，for example，look quite like words：«MIX» could be either a word or a Roman numeral．In Chinese， traditional characters for numbers are formally identical to those for words，四 for example being a numeral＇ 4 ＇and a word si＇four＇．In other societies，includ－ ing the Mayan one，number symbols such as（25）look rather different from writing symbols such as（26）．
（25）$\because$＂ 17 ’
（26）＇fish＇
Children in countries that use similar－looking letters and numbers some－ times confuse the two sets．When 4 －and 5 －year－olds in such countries are asked to name visually presented letters，their errors are typically the names of other letters．Errors that aren＇t letter names are often numbers，sometimes the names of numbers that are visually similar to the presented letters．For
example，US children may call «B＞＇eight’ and Israeli children may call צ， the letter tsadik，＇four＇（Treiman，Kessler，\＆Pollo，2006；Treiman，Levin，\＆ Kessler，2007）．We have seen US children who include some numbers when asked to write words，although we know of no systematic studies on this point． Although d－type numbers such as 〈7〉 and 〈9〉 outnumber b－type numbers， children tend to reverse the d－type numbers more often than the b－type ones （Fischer \＆Tazouti，2012；Treiman \＆Kessler，2011）．This latter result supports the idea that children treat letters and digits as a class for some purposes． Children may calculate statistics on the number of b－type and d－type forms pooling across the two sets，and the b－type forms win out when the sets are combined．Children＇s tendency to treat letters and digits as a class reflects the graphic similarities between the two systems together with other similarities that were mentioned in chapter 5 ，including the fact that the symbols are often intermingled in texts．

## 8．2．2 Learning About Contrasts Among the Shapes of Writing

For some purposes，such as distinguishing writing from other types of marks， it suffices to treat the elements of writing as a set and to focus on the visual similarities among them．For many other purposes，it is important to distin－ guish among the elements of a script．We turn now to the question of how children learn to do this．

Children could learn about the contrasts among the symbols of writing based on experience with texts that contain more than one symbol，experience with isolated symbols，or both．Learning from texts requires children to seg－ ment the writing．For texts that are printed in letters of the Latin alphabet，it is fairly clear that words consist of freestanding letters．However，some forms of writing chunk elements in ways that can disguise their identities and make them meld together．In the Devanāgarī script used for Hindi and several other languages，for example，most elements have a solid bar at the top that con－ nects with those of adjacent elements in the same word．The bar may make it harder to perceive that a word，such as देवनागरी Devanāgarī，is made up of constituents．However，because the bar is so constant and always in the same position，a child may conclude，with approximate correctness，that there are individual entities hanging from the bar．A somewhat similar situation arises in connected cursive writing using the Latin alphabet．The fact that the let－ ters connect impedes segmentation，but the fact that they mostly connect at the bottom may make the task easier than it would otherwise be．Issues of segmentation can also arise when the elements in a syllable are compacted into a fixed space，such as a square in the Korean hangeul writing system． Compacting symbols tends to cramp them together and make segmentation difficult．For example，the hangeul syllable gug is written as in（27），whose component parts can be hard to tease apart unless one is already thoroughly familiar with the constituent letters．Such difficulties are avoided when indi－ vidual symbols are presented．
（27）
국 gug＇nation＇

| ᄀ | $\top$ | $\neg$ |
| :--- | :--- | :--- |
| g | u | g |

Once the individual elements of writing have been segmented from the flow， children must learn that they are defined by their shapes，specifically by their two－dimensional shapes on the planar surface．Children＇s prior experiences have often been with three－dimensional objects．These offer visual depth and haptic cues，which two－dimensional objects lack．As a result，two－dimensional objects are harder for children to tell apart than three－dimensional objects （Etaugh \＆Van Sickle，1971；Falk，1968；Stevenson \＆McBee，1958）．

Another difficulty in learning about letters is that most of the shapes are unfamiliar．The only two Latin letter shapes that are likely to be familiar to chil－ dren in their entirety are $\langle\mathrm{O}\rangle$ ，which children know as a circle，and $\langle\mathrm{X}\rangle$ ，which children may know from games such as tic－tac－toe（noughts－and－crosses）． Children＇s previous experience with these two－dimensional shapes probably helps them learn about these shapes as letters（Treiman，Levin et al．，2007）． Children sometimes try to relate the shapes of letters or parts thereof to those of familiar two－or three－dimensional objects，as when a 2 －year－old related 〈H〉 to a ladder and 〈T〉 to a hammer（Sinclair \＆Golan，2002）．As we discuss in $\int 8.4$ ，some teaching devices encourage children to do this．

Shape is critical in learning about letters and distinguishing them from one another．Children must learn，for example，that «D＞formed with black pen on white paper belongs to the same category as «D＞cut from red cardboard but belongs to a different category from «B» formed with black pen on white paper． Fortunately for children，shape is important for many of the categories that they already know．For example，children know that cups have a characteristic shape although they may differ from one another in color，material，and size． A 20－month－old who uses the word moon when looking at the moon，when playing with a half－moon shaped lemon slice，and when touching a circular chrome dial on a dishwasher is attending to shape as opposed to other proper－ ties（Bowerman，1978）．So are the 3 －year－olds who，after being told that a blue， wooden，U－shaped object is a called a dax，extend that label to a cloth－covered object of the same shape but not to a blue wooden object of a different shape （Landau，Smith，\＆Jones，1988）．

Although shape is important for the categorization of many objects in children＇s worlds，it isn＇t always the most important characteristic．Color is sometimes critical．If a lime were dyed yellow，for example，people would prob－ ably call it a lemon．Function can be important too，especially for artifacts．For example，the 2－year－olds in one experiment learned the word tilfer to refer to a gadget that rings a bell when a lever is pressed．The children tended to extend that label to gadgets that were shaped differently but that functioned similarly （Kemler Nelson，Russell，Duke，\＆Jones，2000）．As these examples show，chil－ dren＇s prior experiences with objects have prepared them to attend to a variety of characteristics，not only to objects＇shapes．

By the age of 3，children appear to know that shape is particularly impor－ tant for making a letter the particular letter that it is．They are more likely to describe a letter than a picture by its shape，and they more likely to talk about attributes such as color for pictures than for letters（Robins et al．，2012）． Further evidence about the primacy of shape over color in the case of letters comes from a study cited by E．J．Gibson（1969）in which 5 －year－olds were pre－ sented with novel letters in different colors and were asked to learn the letters＇ names．After a number of practice sessions，the children were asked to identify black versions of the same shapes．The 5 －year－olds did well，showing that they considered shape more important than color for categorization．However，the 5－year－olds tended to remember the colors in which the letters were originally presented，whereas a group of 9 －year－olds did not．The older children，who were more experienced with letters，seemed to have narrowed their focus to the letters＇shapes．

Even when children know that shape is critical for letters，the specific aspects of shape on which they must focus may be different for letters than for other objects．Left－right orientation isn＇t critical for most objects in the natu－ ral world and for many objects made by humans，including two－dimensional ones．For example，one can draw a truck with the cab either on the left or the right；it＇s a truck either way．In writing，however，left－right orientation is often important．Reversing a letter may cause it to turn into another letter in certain scripts，as when 〈b＞becomes＜d＞．In other cases，as when 〈j＞is written back－ wards or when the components of 和 hé＇gentle＇are reversed，the result isn＇t a symbol of the writing system．Studies of children＇s ability to visually discrimi－ nate among lowercase letters of the Latin script，copy letters，and print letters from memory show frequent confusions involving the mirror－image pairs＜b＞ and 〈 d$\rangle$ and 〈p＞and «q＞（Courrieu \＆De Falco，1989；Lewis \＆Lewis，1965； Treiman \＆Kessler，2011）．Indeed，English speakers sometimes tell people to mind their $p$ s and qs as a way of telling them to act properly．Children see the difference between the mirror－image forms，but they may not grasp its importance for classification．The deliberate reversal of $\langle\mathrm{R}\rangle$ in the logo（28） （at the time of this writing the largest toy retailer in the world），surely doesn＇t help children learn that left－right orientation is important for letters．Letters such as $\langle\mathrm{H}\rangle$ and $\langle\mathrm{T}\rangle$ ，which are symmetrical about the vertical axis，are easier than asymmetrical letters to copy and to produce from memory（Treiman \＆ Kessler，2011），and effects of symmetry have been found for Chinese charac－ ters as well（Yin \＆Treiman，2013）．

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Letters that change their identity when inverted also cause some difficul－ ties for children．Learners of the Latin script sometimes confuse «b＞with＜p＞ and 〈d＞with 〈q＞in perceptual tasks（Courrieu \＆De Falco，1989；Davidson， 1935），and they sometimes invert letters when copying them（Hildreth，1932；

Lewis \＆Lewis，1965）．According to these studies，up－down confusions are less common with letters of the Latin alphabet than left－right confusions such as $\langle b\rangle /\langle d\rangle$ and $\langle p\rangle /\langle q\rangle$ ．This difference reflects，in part，the way in which chil－ dren＇s attention has been molded by their previous experiences with objects． Children pay attention to whether their cup is upright or overturned because juice stays in the cup in the former case and spills in the latter．They may use different labels for the two situations：right side up and upside down．Right－ left orientation is usually less important．

Letters that change their identity when rotated also cause some difficulties for beginners，although not as many as left－right reversals．Among the lower－ case Latin letters，several pairs are rotated versions of the same shape，includ－ ing in many sans serif fonts＜u＞and＜n＞and＜d＞and＜p＞．Young children may confuse such pairs in perceptual tasks（Courrieu \＆De Falco，1989；Davidson， 1935；E．J．Gibson，Gibson，Pick，\＆Osser，1962），and they may rotate letters when copying them（Hildreth，1932；Lewis \＆Lewis，1965）．Rotation is a fea－ ture over which children often generalize for real－world objects and drawings． However，some of children＇s experiences have prepared them to attend to dif－ ferences in rotation．For example，a doll placed upright stays standing，whereas one placed at a 45 －degree angle to the table falls．

No pair of uppercase Latin letters is identical except for right－left or up－ down reversal，and in this respect uppercase letters offer fewer possibilities for confusion than lowercase ones．However，〈J＞is similar to 〈L＞when reversed， and $\langle M\rangle$ is similar to $\langle W\rangle$ when upended．Also，$\langle N\rangle$ and $\langle Z\rangle$ are virtually identi－ cal when rotated 90 degrees．Among the US 4 －and 5 －year－olds in one study， confusions between $\langle M\rangle$ and $\langle W\rangle$ were one of the most common mistakes （Treiman et al．，2006）．

Forms that differ only in the presence of a straight line versus a curve（e．g．， $\langle U\rangle$ versus $\langle\vee\rangle$ ）also cause some difficulties for children（E．J．Gibson et al．， 1962）．Indeed，the distinction between straight and curved lines is sometimes ignored with real and drawn objects：A fishing pole is a fishing pole whether it is straight or bent under the weight of a fish．But children attend to the curving of lines in other situations：They know that a shelf that bows with the weight of the toys piled on it may break．Children also make some confusions between open and closed forms that are similar in other respects（E．J．Gibson et al．，1962）．Confusions between open and closed forms and between rounded and curved forms are less common than reversal and rotation errors，however （Courrieu \＆De Falco，1989）．

Some pairs of letters contrast in one small detail，such as the length or addi－ tion of a line．Learners of the Latin alphabet sometimes confuse pairs such as ＜n＞and 〈h＞in perceptual tasks（Courrieu \＆De Falco，1989）．As another exam－ ple，learners of Hebrew sometimes confuse ו／vav／and i／zajin／（Treiman， Levin et al．，2007）．Such errors reflect，in part，children＇s experiences with two－ and three－dimensional objects．A lamp whose base is camouflaged by a curtain is still a lamp；a drawing of a person that omits the ears is still a person．Motor and perceptual limitations also contribute to errors involving small details of
letter shape．Good motor skills are needed，for example，to produce an «h＞that clearly differs from an＜n＞．

Given the nature of writing＇s symbols，a transformation can affect the cat－ egorization of some letters but not others．For example，changing the angle where the descender of $\langle y\rangle$ meets the base into a curve doesn＇t change the letter＇s identity．Changing this same angle in＜v＞into a curve does change the letter＇s identity．The addition of a short line is another transformation that sometimes changes a letter＇s category，as with＜ F$\rangle$ to＜ E$\rangle$ and sometimes doesn＇t，as when writing a letter in a serif rather than sans serif font．The child who copied 〈E〉 as in（29）（Simner，1982）apparently didn＇t know this． Systematic studies confirm that children who have learned that a certain visual change makes a difference in some cases tend to assume that it makes a difference in other cases（Pick，1965）．Although changing an angle to a curve or adding a line doesn＇t always change the identity of a Latin letter，completing a curve always does．This may help explain why learners of the Latin alphabet are less likely to confuse «C〉 with «O〉 than with «G〉（Treiman et al．，2006）．

## （29） <br> 

Position of a letter relative to the line of print is occasionally relevant for dis－ tinguishing between letters，and this causes difficulty for children．For example， learners of Hebrew sometimes confuse $7 / \mathrm{kaf}$ so＇fit／and ר／rej S／—letters that are very close in shape，where the first extends a bit below the line of print and the second doesn＇t（Treiman，Levin et al．，2007）．Fortunately for children， it is quite uncommon for the major difference between two letters to be in location relative to the line of print rather than shape．But lack of attention to a shape＇s position relative to the line of print can cause children to place a lowercase form such as $\langle\mathrm{g}\rangle$ on the line of print rather than with the descender below the line，as it should be（Lewis \＆Lewis，1965）．

## 8．2．3 Production

Producing shapes requires time and attention，and these resources are more available when the writer isn＇t trying to do many other things at the same time． Thus，people tend to write neater and more legible letters when they are copying a text than when they are performing the more demanding task of construct－ ing one（J．S．Brown，McDonald，Brown，\＆Carr，1988；Graham，Weintraub， Berninger，\＆Schafer，1998）．Constructing a spelling for a novel word demands attention too，decreasing the fluency of handwriting movements even in adults （Tucha，Trumpp，\＆Lange，2004）．The differences between copying a text and composing one are larger for younger children than for older ones，indicat－ ing that letter production is especially effortful for beginners（Graham et al．， 1998）．Indeed，beginners must pay so much attention to letter formation that they may consider the ability to form difficult letters the hallmark of a good writer．One 6 －year－old showed this belief when，after hearing Harold Pinter
introduced as a very good writer，he approached the famous playwright．The child asked Mr．Pinter if he could write the letter 〈W〉（Gussow，1996，as cited in Graham，Weintraub \＆Berninger，2001）．

The amount of time and effort that people devote to letter production depends on what they consider acceptable in a particular situation．When writ－ ing a note for others to read，people try harder to produce legible letters than when writing a note meant only for themselves（Zimmer，1982）．When asked to write especially quickly，people exert less time and effort than when given no special instructions about speed（J．S．Brown et al．，1988；Weintraub \＆Graham， 1998）．People may write more quickly by modifying certain letterforms，such as using the crossbar of a＜t＞to connect it to a following 〈h＞rather connect－ ing the two letters at the base，as in more typical connected writing（Sassoon， Nimmo－Smith，\＆Wing，1989）．Although this change doesn＇t necessarily hurt legibility，other changes made under pressure for speed－such as failing to cross a＜t＞－do．As a result，writing produced under pressure for speed typi－ cally suffers in legibility（J．S．Brown et al．，1988；Weintraub \＆Graham，1998）．

When writing，as when doing other things，people tend to do what produces satisfactory results at the time．They don＇t necessarily do what will produce the best long－term results．Thus，people often type using just their index fingers rather than all their fingers，and they may search for keys visually rather than learning their positions and locating them without looking．For novices，this hunt and peck method is quicker than trying to type by touch（Yechiam，Erev，Yehene， \＆Gopher，2003）．Many people persist in using the hunt and peck method，not spending the extra time and effort to learn the more efficient method．

The historical pressure toward economy of handwritten production means that letters in general tend to be relatively simple．Forms that contain few strokes，such as simplified Chinese 厂＇factory＇，tend to be easier to write than forms that contain more strokes，such as the traditional form of the same char－ acter，廠（Ke，1996；Yin \＆Treiman，2013；for similar findings with letters of the Latin alphabet：Lewis \＆Lewis，1965；Stennett，Smythe，Hardy，\＆Wilson，1972； Treiman \＆Kessler，2011）．

Children－at least those in the modern carpentered world—have some dif－ ficulty drawing lines that aren＇t perpendicular；they tend to make angles more like right angles than they really are（Ibbotson \＆Bryant，1976）．Letters such as $\langle\mathrm{H}\rangle$ ，which have only horizontal and vertical lines，are thus easier for chil－ dren to copy than letters such as 〈K〉，which include diagonal lines（Lewis \＆ Lewis，1965）．Forming some letters，including 〈S〉，requires abrupt changes in curvature，which can be difficult（Meulenbroek \＆Van Galen，1990）．Children sometimes respond to this difficulty by making a separate movement for each part of a curve rather than using a single fluid movement．Thus，they may not write $\langle\mathrm{S}\rangle$ with a single movement，as adults would normally do．

Most symbols of writing contain more than one segment．Beginning writers may deal with one segment at a time－planning the first segment，then car－ rying it out，then planning the second segment，and so on．They may not pro－ duce the segments in the most economical orders or directions．For example，
some Japanese 5 －year－olds，when asked to copy ひ，start with the large semi－ circle，go back to the top to form one of the short lines on the side，and then go back to the other end to form the other small line（Nihei，1983）．This pattern is inefficient，for it requires raising the writing implement in the middle of the character．In typing，a single key press often suffices to produce a symbol．But some symbols，such as uppercase letters，may require more than one key to be pressed．Writers may eliminate these additional key presses when pressed for speed，as when writing a text message in all lowercase letters．

With practice，children produce letters faster and more fluently．They start to show an advantage for forms that are part of their writing system over com－ parable forms that aren＇t．Thus，the 6 －year－olds in one study were faster to pro－ duce a circle when the task was to draw a circle for the letter « O » than when the task was to draw it for a porthole on a ship，and the writing advantage appeared to increase over the next few years（Adi－Japha \＆Freeman，2001）．Increases in the speed of written production with practice can be dramatic．In one study， US children showed a sixfold increase in handwriting speed between the ages of about 6 and 14 （Graham et al．，1998）．

There are many reasons why speed of letter production improves so dra－ matically with practice．For handwriting，one reason is that the motor move－ ments needed to form a letter are planned in advance．The movement pattern for a well－practiced Latin letter becomes a chunk rather than a series of sepa－ rate movements（Teulings，Thomassen，\＆Van Galen，1983）．Because planning is done before the letter is produced，production of the first segment of a letter may not speed up as much with practice as production of the later segments does（Portier，van Galen，\＆Meulenbroek，1990）．The components within a complex symbol may be chunked as well．Thus，Chinese children are better at copying unfamiliar characters that contain familiar components than those that contain one or more unfamiliar components（Anderson et al．，2013；Pak et al．，2005）．In addition，people may plan groups of letters in advance．For example，writers of French appear to plan how to write the＜an» of＜chanter＞ ＇to sing＇while they are forming the＜h＞（Kandel，Soler，Valdois，\＆Gros，2006）．

With practice，writers are increasingly efficient in how they produce the segments of a symbol，adopting patterns that are consistent across a number of symbols．For example，users of the Latin script may consistently produce vertical lines before horizontal ones．Even if they are taught to write 〈T＞with the horizontal line first，as done in some schools，they may form the verti－ cal line first－the same sequence they use with other letters（Simner，1981）． Writers of Chinese develop particular stroke sequences for forming common components of characters，sometimes departing from stroke sequences they are taught（Li，Yang，Poon，\＆Fung，2007）．

Another reason why handwriting speeds up with practice is that people modify shapes in service of economy．For example，university students may produce the uppercase cursive form of 〈 X$\rangle$ as（30）after having been taught as children to write（31）（Schell \＆Burns，1963）．Experienced writers may also develop special and easily produced shapes for common letter sequences．

As mentioned earlier，some teenagers and adults regularly use the crossbar of $t$ to connect it to a following $h$（Sassoon et al．，1989）．Some convert the upstroke normally used to round off $o$ into the upstroke of a following $f$ ， producing（32）（Epstein，Hartford，\＆Tumarkin，1961）．People may also mix connected and unconnected（block）letters within a text rather than using a single form as they were taught to do（Graham，Weintraub，\＆Berninger， 1998）．Such changes，which reflect long practice with writing，tend to be more common among more educated people than among less educated ones－at least during the time in which educated people often wrote by hand（Epstein et al．，1961）．
（30）$\times$
（31）
$32)$

Variations in symbol shape that make handwriting economical can also make it more individual and potentially more expressive．For example，the special shapes that writers develop for common letter sequences help to distin－ guish among writers（Eldridge，Nimmo－Smith，Wing，\＆Totty，1984）．Friends and law enforcement officials can sometimes use such cues to determine a writer＇s identity．However，variations in service of economy can decrease con－ trast，making writing harder to read．For example，some experienced writers of French produce a horizontal line for both the acute 〈＇〉 and grave ‘〉 accent marks，causing ambiguity between the phonograms «é»／e／as in dés＇dice’ and ＜è＞$/ \varepsilon /$ as in dès＇from＇．These things help to explain why adults＇handwritten letters and numbers tend to be harder to read than those of younger people who are still in school（Newland，1930，1932）．

Typists can＇t get faster by modifying the shapes of letters，but they can press the keys more quickly．Beginners work sequentially，locating one key（either by looking at the keyboard or by retrieving the location from memory），press－ ing it，and then locating the next key．They type double letters such as «bb＞ faster than other two－letter sequences because they have already found the key（Gentner，1983）．Skilled typists overlap their movements，starting to move toward the following key while pressing the current one（McLeod \＆Hume， 1994；Rumelhart \＆Norman，1982）．This is easiest to do when the next key needs to be pressed with the opposite hand，intermediate in difficulty when the next key requires another finger of the same hand，and hard to do when the next key requires the same finger of the hand currently in use．In skilled typ－ ists，therefore，the time between successive key presses is shortest in the first situation，intermediate in the second，and longest in the third（Gentner，1983； Kinkead，1975；Terzuolo \＆Viviani，1980）．Also，the time between successive key presses is less when the next letter is a short reach from the current one
than when it is more distant（Rumelhart \＆Norman，1982）．Typists，like hand writers，develop efficient ways of overlapping the movements needed for com－ mon letter sequences．This helps them to type common groups more quickly than less common ones（Terzuolo \＆Viviani，1980）．

Testifying to the importance of practice，children are more knowledgeable about the shapes of letters that they have seen and practiced often than about the shapes of other letters．For younger children in many societies，letter frequency is to some extent an individual matter，tied in part to the letters in the form of the child＇s personal name that is most commonly used with the child．Brad＇s parents talk more about «B〉 than Greg＇s parents，for example，and they show him this and other letters of his name when they appear on billboards or T－shirts．Brad may see his name on the door of his room at home or over his coat hook at his daycare cen－ ter，and he may also try to write his name．Indeed，printing the name is the most frequent literacy－related activity in which Canadian 4 －to 6 －year－olds are reported to engage at home，and the one most likely to be initiated by the child（Levy，Gong， Hessels，Evans，\＆Jared，2006）．Reflecting the high frequency of Brad＇s name in his experience and the importance that he attaches to it，he is likely to know more about the shapes of the letters in his name than about the shapes of other letters， even other letters such as＜e＞that are more frequent in printed words generally． This own－name advantage appears when 3－to 6－year－olds label letter shapes by name，when they produce the shapes，and when they perform other tasks requir－ ing letter shape recognition；it has been reported for children in countries as diverse as Australia，Brazil，France，and the United States（Bouchière，Ponce，\＆ Foulin，2010；Treiman et al．，2006；Treiman \＆Broderick，1998；Vinter \＆Chartrel， 2008）．In countries where children are usually called by their given names alone， the own－name advantage is particularly strong for the first letter of the given name．In the Latin alphabet，the first letter of the name almost always appears in uppercase；it is usually taller than some or all of the other letters．However，this doesn＇t completely explain children＇s better performance on the first letter of their name than on the later letters．This is shown by the fact that the same phenom－ enon is found in learners of Hebrew，which doesn＇t have special uppercase forms （Treiman，Levin et al．，2007）．

Young children＇s knowledge about the shape of their name＇s first letter can be rather detailed．Before their fourth birthday，US children can sometimes rule out versions of their name that differ from the correct version in one small detail involving the shape of the initial letter，as when the $\langle\mathrm{B}\rangle$ of $\langle\mathrm{Brad}\rangle$ is replaced with $\langle\mathrm{P}\rangle$ ．Children tend to do less well with changes to letters beyond the first（Treiman，Cohen et al．，2007）．

Children＇s knowledge about the shapes of letters they have seen and prac－ ticed often，including the letters in their own names，is to some extent spe－ cific to the particular shapes they have experienced．For example，US parents and preschool teachers write Brad＇s name for him as 〈BRAD＞or «Brad»；they hardly ever write 〈brad»．By the age of around $4^{1 / 2}$ or 5 ，Brad is more likely to accept «BRAD» and «Brad» as spellings of his name than to accept «brad» （Treiman，Cohen et al．，2007）．Brad shows a larger advantage over Greg on
«B〉, the specific form he has seen in his name, than on «b» (Treiman \& Kessler, 2004). However, he shows some advantage over Greg on «b» as well.

As children get older, the frequency with which they hear about and see letters becomes less an individual matter, less tied to the letters in the child's own name and more tied to the letters that occur in print more generally (Robins et al., 2013). Thus, between around 4 and 6 years of age, letter frequency as calculated on the basis of book print shows an increasing relationship to accuracy in copying letters, recognizing the shapes by name, and retrieving the shapes from memory (Bouchière et al., 2010; Treiman \& Kessler, 2011). The frequency of a letter in one's recent experience is important too. For example, adults are quicker to retrieve a newly learned shape when the previous trial of an experiment involved the same shape than when it involved a different one (Van Galen, 1980).

### 8.2.4 Learning Variant Forms of Shapes

In some cases, people must learn alternate shapes for the same letter. Children's experience with within-category variability in other domains probably prepares them, to some extent, for the variability that they encounter with letters. For example, children know that some variation in shape is allowed within the category of cups: Tall skinny cups and short squat cups are both cups. Indeed, children expect to find some variation within a category; objects in the world aren't usually carbon copies of one another.

Many sorts of variability occur with letters. In Kannaḍa, each letter has a primary form, which is used in some contexts, and a secondary form, which is used in other contexts. Children learn the primary forms of the consonants first. They are better at producing secondary forms that are a miniature version of the primary form than secondary forms that have different shapes altogether (Nag, Treiman, \& Snowling, 2010). For example, (33) shows, first, the consonant for $/ \mathrm{\eta}$ / in its primary form, which by itself spells the syllable / $\eta$ ว/, with the inherent vowel used in this abugida alphabet $(\mathbb{} 2.5)$. The second form shows the same consonant with its secondary form written underneath it, a combination that spells the sequence $/ \mathrm{\eta} \eta$ ə/. In this case, the two forms are identical except for size. In (34), the situation is analogous, with the second form showing a secondary $/ \mathrm{m} /$ under a primary $/ \mathrm{m} /$. These two shapes are very different, causing difficulty for children.
(33) ణ /ఇə/, ణ /nఇว/

In many countries that use the Latin script, children usually learn the uppercase forms first. They tend to be better at lowercase forms that differ only in size from their uppercase counterparts, such as 〈c>, than on ones that differ in shape, such as «r> (Treiman \& Kessler, 2003, 2004; Turnbull, Bowles, Skibbe, Justice, \& Wiggins, 2010).

We suspect that uppercase Latin letters are intrinsically easier for beginners to perceive and produce than lowercase ones. Pairs of uppercase letters tend to be less similar to one another than the corresponding pairs of lowercase letters, according to our analyses of similarity ratings collected by Simpson, Mousikou, Montoya, and Defior (2013), and no pair of uppercase letters contrasts only in orientation. Uppercase letters are larger than lowercase ones as well, and more likely to be horizontally or vertically symmetrical. These things probably mean that, without counteracting factors-such as educational programs that stress lowercase letters on the belief that these are the ones children need most-uppercase Latin letters are easier to learn than lowercase ones. These considerations help to explain why US parents almost always use uppercase letters when showing young children letters of the alphabet and when writing individual letters for them and why they sometimes use all uppercase letters when writing the child's name (Treiman, Cohen et al., 2007). Parents in England sometimes do the same, even though the schools stress lowercase letters from the beginning. Lowercase letters do win out in economy, being simpler on average than uppercase letters. As people write more often, this comes to be advantageous.

The Latin script and some other scripts include special forms that occur in connected writing. Modern children in a number of countries, including the United States, often learn to produce and read connected writing somewhere between the second and the fourth years of schooling, well after block (unconnected) letters are known. Children in these countries have little exposure to connected writing before this age. Some US schools now forgo formal teaching of connected writing altogether, typing being considered more important. In certain other countries where tradition reigns more strongly, including the Czech Republic, Poland, and France, children are expected to produce connected writing as early as 5-6 years of age and may not be taught to produce block letters at all. Children in these countries may have a fair amount of exposure to connected writing even before this age. In French schools, for example, the names of 3 - to 5-year-olds often appear above their lockers and coat racks in both connected and unconnected forms. Children's experience with block letters carries over to connected writing, so that French 4 -year-olds perform better in visual recognition tasks with connected forms that are similar in shape to the corresponding block forms, as with (35) for 〈w $\langle$, than with connected forms that are less similar in shape to the corresponding block forms, as with (36) for $\langle\mathrm{f}\rangle$ Vinter \& Chartrel, 2008).
(35) $W$

Connected writing poses some difficulties for beginners. It requires writers to produce continuous lines, which as mentioned earlier can be difficult for
children when the lines change direction. Some parts of connected writing require a lift of the pen, and the same letter may have different forms depending on the adjacent letter. A further complication is that it may be difficult to perceive the letters of connected writing as separate units. On the positive side, learners of the Latin alphabet are spared some of the choices about where to begin letters that they face with manuscript forms, since they are often taught to begin the connected forms of all lowercase letters on the line of writing. Also, it may be easier to leave the appropriate space between words when all of the letters in a word are connected to one another. Confusions between letters such as «b> and «d> may be reduced.

Variant forms of a letter are not restricted to connected versus unconnected forms. Variation also occurs when letters are written in different styles or fonts. The letters in trademarks and advertising often show a good deal of variability. The large yellow «M» in the McDonald's logo (37) is rather different, for example, from the typical form of this letter. One child learned to label this yellow form as /any/ (for "McDonald's") at 1 year, 8 months of age but didn't recognize the letter in (38), the logo for a chain of stores, as a member of the same category until around her second birthday (Baghban, 1984). There is probably less gap between recognizing a letter in one style and recognizing it in another when differences in shape are small and when children have learned that color is irrelevant to the categorization of letters.
(37)
$\because$
(38)


People sometimes use different letter shapes in writing than in reading. For example, schoolchildren in such countries as the Czech Republic and France may be taught to write connected letters but to read unconnected ones. As another example, users of the Latin alphabet may produce forms that look like $\langle a\rangle$ and $\langle\mathrm{g}\rangle$ but read «a> and $\langle\mathrm{g}\rangle$. These discrepancies have little impact by the time children have been reading and writing for a year or two (de Lange, Esterhuizen, \& Beatty, 1993; Walker \& Reynolds, 2003), but they might cause some problems early on.

The considerations we have been discussing help to explain why diacritics cause difficulty for both children and adults. Forms that contrast only in the presence or absence of a diacritic or only in the identity of a diacritic are easily confused when the diacritic is small, as it is for many scripts. Indeed, pairs of Latin letters that differ in these ways are rated as much more similar than other pairs of letters (Simpson et al., 2013). Five-year-old learners of Arabic sometimes confuse letters that differ only in the presence or the absence of a dot, such as /ha:?/ and /(3i:m/, the first two letters in (39). Children may also
confuse versions of the same basic form that have the same diacritic in different locations, such as /ब̄3i:m/ and /xa:3/, the last two letters in (39) (Levin, Saiegh-Haddad, Hende, \& Ziv, 2008).


A further problem is that certain diacritics contrast with one another only minimally. The difference between a grave and an acute accent, for example, involves just the orientation of a small line. Moreover, typing a letter with a diacritic sometimes requires an extra key press. In handwriting, producing a letter with a diacritic often requires lifting the writing instrument to produce a form that is separate from the base. To make production more economical, writers may produce all of the diacritics for a word after writing the rest of it, especially when the other parts of the word can be written as a single connected unit. In Hindi, where most of the letters have a horizontal bar at the top, it is common for writers to first write the parts of the word that go below the bars, then to draw the bar in a single continuous movement. Often people then write, in a last pass, all of the diacritics that appear above the bar. If diacritics for the whole word are added last, there is a danger of leaving them out or putting them in the wrong place. Errors of this kind, which occur in users of several scripts (Nag et al., 2010; Protopapas et al., 2013), probably reflect the graphic characteristics of the diacritics in addition to the aspects of phonology that they represent.

### 8.3 Nonarbitrary Links Between Symbol Shapes and Functions

It is important to learn about the basic shapes of one's writing system as graphic objects. However, knowing the shapes without knowing how they symbolize language would be an empty skill. Learning the associations between the basic symbols of writing and the linguistic units for which they stand is critical. People generally find it harder to learn arbitrary associations than nonarbitrary associations, and it takes a good deal of practice to fix arbitrary associations in memory. Therefore, one might think to design a writing system in which the associations between symbols and the linguistic units for which they stand were motivated rather than arbitrary. This is difficult to do, however. It is especially difficult in phonographic writing systems, where symbols represent sounds. There are nevertheless some cases in which the links between symbol shapes and functions aren't arbitrary, and we consider those cases here.

In some phonographic writing systems, the shape of a letter provides a clue as to whether the letter corresponds to a vowel or a consonant. Consider Korean hangeul, where vowel letters consist of long straight lines, modified, if at all, by shorter lines abutting them in the middle (40). Consonants have
other shapes（41）．Children could potentially divide letters into categories based on their outer form．They could use the surface－level categories to help learn that there are differences in function between the two sets．

（41）ᄀᄂㄷㄹロㅂㅅスステヨ프
In abugida writing systems（ $\mathbb{\$ 2 . 5 ) \text { ，including the Devanāgarī script used for }}$ Hindi and several other languages $(\mathbb{}$ 2．6．2），most vowels are written by adding diacritical marks to the basic consonant symbols．To प，for example，which represents／ p ／or／ p ／，can be added a diacritic to show that／ p ／is followed by ／e：／．The diacritics may be added above the base characters（42），below them （43），or they may consist in part or in whole of a vertical line next to the base character（44）．In any case，the diacritic is discernible as subordinate to and different from the base character．Here，too，surface distinctions could provide a clue about a difference in linguistic function．
（42）पे $/ \mathrm{pe}: /$ ，पै $/ \mathrm{pai} /$
（43）पु／pu／，पू／pu：／

## （44）पा／pa：／，पि／pi／，पी／pi：／，पो／po：／，पौ／pau／

The shapes of the Latin letters offer no strong cues to a letter＇s status as a consonant or vowel．With lowercase letters，a possible cue is that vowels other than 〈y〉，which sometimes represents vowels，lack ascenders and descenders． Lowercase vowels may have developed compact shapes because they are used so often，as mentioned earlier in this chapter．However，this cue is by no means foolproof，and the lowercase forms of some consonant letters，like «c» and «n»， also lack ascenders and descenders．In some languages that that use the Latin script，the presence of a diacritic clues consonant or vowel status．For example， the great majority of vowels in Vietnamese have at least one diacritic（ $\mathbb{2 . 2 . 2 . 5 )}$ ， while no consonant does．

The shape of a symbol in an alphabetic writing system sometimes corre－ lates with other aspects of the symbol＇s function．In Hebrew，letter shape cor－ relates with word position．Four of the five word－final letters have a descender of a kind that doesn＇t occur in most other letters（ $\$ 8.1 .5$ ）．The shapes of these letters could potentially help learners identify them as special word－final forms．However，Hebrew text contains a more general visual cue to word－final position：blank space between words．Visual features could also help children divide the Latin letters into uppercase and lowercase，as mentioned earlier in this chapter，and into marks that symbolize phonemes and marks that serve as punctuation，as discussed in chapter 12.

The physical appearance of a symbol sometimes provides a clue to its lin－ guistic category or function，but does the outer form ever pinpoint a symbol＇s exact linguistic function？For phonographic writing systems，a first thought
might be to form shapes that resemble the shape of the vocal apparatus when making the corresponding sounds，devising shapes that are iconic in a holis－ tic way．But it would be difficult to do this while maintaining economy in the symbols of writing．Realistic pictures would need to be large and detailed－ time－consuming to produce by hand and wasteful of space．Moreover，some letters would look alike from certain views（／m／，／p／，and／b／all have closed lips，for example）and many speech sounds change during their production． Voiced sounds are characterized by a vibration of the vocal cords，and how could a snapshot show that pictorially？For these reasons，no phonographic writing system has symbols that are fully iconic．Even attempts at phonetic iconicity，such as those we describe in the following paragraphs，are rare．

Korean，unusual among writing systems，has several letter shapes that were designed to be phonetically iconic．As we discussed in $\mathbb{\int 2 . 2 . 2 . 4}$ and $\mathbb{\int} .3 .2$ ，the basic consonant symbols were designed to iconically show their place of articu－ lation．For example，velar sounds such as $/ \mathrm{k} /$ show the tongue rising toward the back of the mouth $\neg$ and alveolar sounds like $/ n$／show the tongue rising toward the front of the mouth ᄂ．These shapes are rather abstract，however． Understanding them relies on knowing certain arbitrary conventions，such as the fact that the mouth being pictured is facing left．

Iconicity is more possible for pitch and tone than for segments（ $\left(\frac{2.3 .2}{}\right.$ ）． And it is relatively common in these cases，perhaps suggesting that people derive some benefit from it．The diacritics that developed to show pitch in Greek were basically iconic：〈́⿱亠乂口〉 represented／a／with a high tone（the acute diacritic points up when scanned left to right），and 〈 $\grave{\alpha}\rangle$ represented／a／with a low tone（the grave diacritic points down）．Some variation of this system is used in the International Phonetic Alphabet and several tone languages， such as Vietnamese．This system can be extended to languages that have many tones，several of which are contours，shifting from one pitch to another；the change of pitch is at least as important in such systems as the absolute pitch of the endpoints．In the pīnyīn writing system of China，＜á＞stands for a rising tone：one that starts lower and ends higher，just like the diacritic．The mark is still iconic，but in a slightly different way than in Greek．Similarly，«à＞marks a falling tone，«ă〉a tone that dips then rises，and 〈ā＞a level tone．When tone is indicated by letters，as it is in some writing systems such as the Romanized Popular Alphabet for Hmong，it isn＇t iconic．Writing systems that indicate stress often apply one of the markers for pitch or tone，the acute diacritic＜＇＞ being a favorite．This may be iconic in that stressed vowels are represented by letters that are graphically heavier：«é〉 is visually more prominent than «e〉， just as the stressed syllable is more prominent acoustically．Writers sometimes use uppercase or large letters to indicate emphasis，as in＂we HATE that＂． Prominent letter forms indicate linguistic prominence－iconicity again．

It＇s hard to make the symbols of a phonographic writing system iconic in a holistic way，as we have seen，and few writing systems attempt to do that． Another possible way to motivate the associations between letter shapes and sounds，a compositional rather than a holistic method，is to analyze sounds
into phonetic components and design shapes that reflect these components. In such a system, a letter would be composed of visual elements, each of which reflects one of the phonetic features of the segment represented by that letter. The building blocks of the system need not be pictorial, however: the symbol for aspiration could be an arbitrary shape rather than a picture of a puff of air. Alexander Melville Bell's Visible Speech, which was designed as a system for teaching spoken language to deaf people, follows these principles. All phonemes are written with symbols that mark their phonetic properties. For example, the symbol for $/ \mathrm{m} /(45)$ contains the arc shape $Ј$, to indicate labial place of articulation, as seen also in the symbols for other labial consonants (46). One end of the arc is terminated by a straight line that shows that air doesn't escape through the mouth. The other end is terminated by a wavy line that indicates that air escapes through the nose, a description of nasal consonants, as seen also in (47). The vertical line in the middle indicates voicing, as seen also in the voiced consonants in (48).
(45) $\Theta / \mathrm{m} /$
(46) D /p/, B /b/
(47) $\leftarrow / n /, \in S / y /$
(48) $\boldsymbol{B} / \mathrm{b} /, \boldsymbol{\omega} / \mathrm{d} /, \omega / \mathrm{J} /$, © $/ \mathrm{j} /, \mathrm{G} / \mathrm{g} /$

However, no writing system that is used every day by a large number of people shows such a high degree of compositionality. One reason is that a highly compositional system wouldn't be economical, causing problems for writers. In addition, a reader who overlooked one part of a letter wouldn't know the sound's value on a particular feature because no other part of the shape provides a redundant cue.

Compositionality of the kind we have been discussing occurs to at least some extent in a few writing systems in everyday use. In Korean, the basic symbols for the various places of articulation for consonants are meant to be iconic, as discussed earlier (Table 2.1). The basic symbols denote sounds that can be held continuously. To the basic symbol can be added a line to indicate a sound that can't be held continuously (the row labeled " +1 line" in Table 2.1), as when ᄃ $/ \mathrm{t}$ / is formed from ᄂ $/ \mathrm{n} /$. A second line (" +2 lines") can be added to that to indicate a sound that is aspirated, as when $E / \mathrm{t}^{\mathrm{h}} /$ is formed from $ᄃ$ $/ t /$. Some of the symbols for the consonants can be doubled to indicate a tense pronunciation, as when $\lambda$ doubles to form 从. This system is clever and elegant, but it has certain inconsistencies. For example, the lines that are added to the basic characters aren't always added in a geometrically precise or consistent way. Because each rule only explains a few characters, Korean speakers generally report that they think of a letter as a whole entity that represents a phoneme, not a complex of components that represent individual features. In Tibetan, as another example, most stop and nasal consonants with the same place of articulation have a similar shape. The patterns have exceptions, and
they are hard to define precisely，but they are readily perceivable．Most of the velar consonants shown in（49）look similar to one another，as do the palatal ones in（50），the alveolar ones in（51），and the labial ones in（52）．As these exam－ ples of Korean and Tibetan show，even those writing systems that do represent phonetic features don＇t do so in a highly systematic way．
（49）ग几可下
（50）бぁ Е
（51）ち曰ちす
（52）ひねワ 『
Motivated associations between alphabetic letter shapes and phonetic fea－ tures sometimes arose when a writing system was developed from the ground up，as occurred with Korean．Motivated associations sometimes arose，as well， when a language borrowed a writing system from another language and had to add new symbols to it to represent sounds that weren＇t in the original lan－ guage．In Arabic，for example，there is no systematic connection between the shapes of letters that represent voiced and voiceless sounds．But when Persian adapted the Arabic script and needed a symbol for the voiced sound $/ \mathrm{g} /$ ，it took the existing symbol for the corresponding voiceless sound $/ \mathrm{k} /$ ，and added a line to it（53）．Because of such adaptations，Persian ended up having more graphic similarities between symbols for similar sounds than scripts nor－ mally do．In some cases，such adaptation is massive enough，and applied with enough intelligent systematicity，that the beginnings of a featural system are seen to overlay the original alphabetic system．Triple dots below the baseline now indicate lack of voicing in Persian（54），and triple dots above a symbol can indicate a postalveolar fricative（55）．
（53）ك $/ \mathrm{k} /$ ，گ／g／

（55）س／s／，ش／f／；j／z／，j／3／
The effort that designers and adaptors of writing systems have sometimes gone to in order to make symbols reflect phonetic features suggests that they expected at least some users of the system to be sensitive to the pattern－ ing．In most cases，though，only a few letters partake in any new patterning． This is because most featural distinctions apply to only a few sounds and also because existing letters are rarely if ever discarded in favor of the new pattern－conservatism．

There is little research on whether users of the systems we have described benefit from the systematic links between symbols＇shapes and the linguistic units for which they stand．We，along with the designers and adaptors of writ－ ing systems just mentioned，suspect that people gradually become sensitive to the patterning，especially if it involves more than just a few symbols．So
in Urdu，where there are 10 aspirated consonants，all written with ofter the symbol for the basic consonant，children may take advantage of that pattern－ ing．The same may be true for Japanese syllabaries，where the diacritic＜＂＞is used to distinguish many pairs of CV syllables that differ in the voicing of the consonant，as in き／ki／and ぎ／gi／．The fact that the distinctions involve only aspiration or voicing may be important here，since language users can ignore those small variations with relative ease．Even if children who are learning a system such as Japanese or Urdu have no real knowledge of compositional－ ity，the fact that similar sounds tend to be written with similar－looking let－ ters makes it easier for others to interpret their spelling errors．A child who is learning English who writes $/ \mathrm{k} /$ with the symbol that is appropriate for the similar－sounding／g／will have produced a symbol that looks rather different from the correct one．A learner of Japanese who makes a voicing confusion will have produced a symbol that looks quite similar to the correct one．

Logographic writing systems，whose symbols represent morphemes，have more opportunity for motivated relationships between shapes and linguistic units than do phonographic writing systems．A number of Chinese characters， as discussed in $\mathbb{\$ 2 . 4 . 2 \text { ，are made up of graphic components that appear in other }}$ characters．Some of these components relate to the pronunciation of the char－ acter，and others to the conceptual category．The latter component may look somewhat like members of the category．For example，口，which derived from a picture of a person＇s mouth，appears in a number of characters that relate to the mouth，including words for＇shout＇and＇spit＇（56）．The other component of the character 叫＇shout＇was chosen because its pronunciation，$j i \bar{u}$ ，is similar to jiào，and it appears in a few other characters with a similar pronunciation （57）．However，the clues are rarely sufficient to allow a writer to construct a character，and they are in some cases misleading．For example，叶＇leaf＇con－ tains the＇mouth＇component but has nothing to do with a mouth．Also，the phonetic similarities are often only approximate．A number of the same pres－ sures that work against motivated associations between shapes and linguistic units in the case of phonographic writing systems also operate in logographic systems．For example，the concept of a mouth could be more reliably elicited by a highly realistic picture of a person＇s mouth than by 口，which could alter－ natively be interpreted as＇square＇or＇hole＇．However，realistic pictures would lack the economy that is important for symbols of writing．
（56）口 kǒu＇mouth＇：叫 jiào＇shout＇，吐 tǔ＇spit＇，叶 yè ‘leaf＇
（57） 4 jī̄u＇join＇：叫 jiào＇shout＇，纠 jiū＇inspect＇，收 shōu＇catch＇
Although the cues that character components provide aren＇t always straightforward，Chinese children take advantage of some of these cues by the age of 7 ．Thus，they learn made－up characters more easily if the components have their typical functions than if they don＇t（Tsai \＆Nunes，1999，2003）． This is true even when the children haven＇t been formally taught about the components．

### 8.4 Formal and Informal Teaching

According to the discovery view of learning, children learn about shapes of symbols in the same general way that they learn about other aspects of writing: without explicit teaching. Specifically, children learn about shapes by looking at them, by hearing people talk about them, by watching people produce them, and by trying to produce them. Formal lessons and corrective feedback are unnecessary. Lessons that focus on isolated units of writing can actually hurt children, according to the discovery view, drawing their attention away from the communicative function of writing. Guidance about shapes can be provided informally, if needed, while children are writing. For example, a teacher might remind a child who is writing a story about King Arthur how to form the letter 〈K〉 or might show the child how to use the shift key on a computer keyboard to produce an uppercase letter. Advocates of direct instruction have a different view, seeing such methods as responding to difficulties that have already occurred rather than heading them off. They see a place for lessons about isolated shapes, lessons that allow students and teacher to focus on the shapes in a way that they wouldn't normally when writing and reading meaningful texts. A further argument for direct instruction is that, left to their own devices, children sometimes develop approaches that work well in the short run, such as hunt and peck typing, but less well in the long run. The research to which we now turn shows that children learn a good deal about symbol shapes in informal ways: by observing them, hearing people talk about them, watching other people produce them, and trying to produce them on their own. However, the research also supports the idea that some instructional time should be spent on the shapes when this is the only goal.

In the United States, parents sometimes talk with even very young children about the letters that appear on food packages, T-shirts, toys, alphabet books, and so on. With children of 1-2 years of age, parents tend to describe letters in terms of their objective attributes. With pictures, in contrast, they tend to use evaluative terms, such as nice or spooky. Starting around the age of 3, parents increasingly talk about the shapes of letters rather than their colors or the materials from which they are made, saying such things as "The $\langle\mathrm{B}\rangle$ has two humps" (Robins et al., 2012). These conversations may help to draw children's attention to letters and inform them some properties of letters are more important than others.

Although seeing letters and hearing them described in terms of their shapes help children to learn about the graphic forms, producing the shapes themselves helps even more. Thus, English 7 - and 8 -year-olds showed better memory for novel letter-like forms after having traced around the shapes with their fingers than after having looked at the shapes for the same amount of time (Hulme, 1979; Hulme, Monk, \& Ives, 1987). French children of around $4^{1 / 2}$ years of age remembered letter shapes better when they copied the letters by hand than when they typed them on a computer keyboard (Longcamp, Zerbato-Poudou, \& Velay, 2005). Similar results have been found when
adults learned novel writing-like symbols (Longcamp et al., 2008; Longcamp, Boucard, Gilhodes, \& Velay, 2006). Producing a letter by hand may be beneficial because it forces the learner to examine all aspects of the shape. Other ways of forcing learners to do that, such as dividing letters into segments and having learners work with the segments, are helpful, too (Courrieu \& De Falco, 1989). What seems to be important, therefore, is that learners perform some action that forces detailed processing of the shape.

Even better than seeing and copying a static shape that has already been formed is seeing a hand produce the shape and then making a copy (D. Hayes, 1982; Søvik, 1976). Watching a letter being produced, whether on paper or in the air or on a Web site that shows an animation, provides information about the order and direction of the movements. On static media such as paper, educators sometimes provide other cues for children, including arrows or numbers to convey information about the order or direction of the movements, or a green dot where a line should start and a red dot where it should stop. However, the 5 - to 6 -year-olds in one study didn't benefit as much from arrows and numbers placed on static forms as from watching a person write the letters (LaNunziata, Cooper, Hill, \& Trap-Porter, 1985).

People can learn about letter shapes without corrective feedback, as shown by the results of a study in which children and adults judged whether various scribbles were the same as or different from a standard (J. J. Gibson \& Gibson, 1955). Initially, participants sometimes overlooked small differences. Their categories become narrower and more specific with practice, even though they received no feedback about correctness. However, feedback helps in the learning of letter shapes (Gotkin \& Eisman, 1969), as in learning more generally. Teachers can provide feedback, or learners can be encouraged to compare their productions to a model. Puzzles in which a letter block either fits or doesn't fit into a cut-out shape provide feedback on every attempt-nonverbal feedback.

Direct instruction about the production of symbol shapes sometimes involves having children trace over lines or connect dots. Children may do this with their fingers, without leaving a trace, or they may do it with a pen or pencil. Teachers may provide practice materials on which the lines over which children trace become fainter and fainter, to the point that children are producing the shapes on their own. Tracing is a rather ineffective way of teaching children to produce novel forms, however. According to one study, it is no more effective than directing children to look at the forms (Naka, 1998). People show better learning of symbol shapes when they practice shapes by writing them than by tracing them (Askov \& Greff, 1975; Hirsch \& Niedermeyer, 1973; Naka, 1998). This difference reflects the fact that practice at one task (tracing) doesn't fully transfer to other related tasks (writing). Also, copying leaves a visual record that learners can compare to the original, whereas tracing with the fingers alone doesn't. When learners copy with the wrong end of the writing instrument, leaving no record, copying is less beneficial than it is normally (Naka, 1998). Copying a shape is harder than tracing it (Birch \& Lefford, 1967), though, helping to explain why
tracing is sometimes used as a teaching method even though it isn＇t highly effective．Copying is easier if an expert guides a learner＇s hand，which also pro－ vides information about the order and direction of the movements．

As we have discussed，the order and direction of movements tend to be consistent from one symbol to another within a writing system．Teachers in countries that use the Latin alphabet don＇t usually explain these conventions to children．When this was done in one study with US 4 －and 5 －year－olds，the children sometimes applied the patterns to letters they weren＇t taught about． For example，children who had been told that the vertical lines of such letters as 〈F〉 and 〈b＞were formed from top to bottom were more likely to form the ver－ tical line of «E〉 that way（Kirk，1981）．Although the children in this and another study（Søvik，1976）benefited from explanations about the nature and order of movements，verbal explanations don＇t always help children（D．Hayes，1982； Silver \＆Rollins，1973）．

One reason why learners of the Latin alphabet don＇t always benefit from verbal explanations about the order in which to produce the segments of letters may be that they don＇t normally learn labels for the segments．For example， English doesn＇t have a widely used colloquial label for the closed curve that appears in 〈 B$\rangle$ ，$\langle\mathrm{R}\rangle$ ，and 〈 P$\rangle$ ．Chinese，in contrast，has widely used labels for strokes，such as héng＇horizontal＇and shù＇vertical＇．Children learn the names of the strokes as a part of early literacy instruction，and teachers tell them which strokes to write for a new character and in which order．Children are also taught such conventions as that horizontal strokes are generally formed before vertical ones that cross them．However，children in many Chinese schools receive little explicit instruction about the fact that complex characters are built from repeatable components．This may contribute to the fact that children sometimes don＇t write complex characters one component at a time （Law，Ki，Chung，Ko，\＆Lam，1998）．When children are taught to analyze com－ plex characters into their components，their ability to write and copy characters improves and they seem more likely to produce the components as chunks （Packard et al．，2006）．

Children are sometimes taught about the shapes of writing＇s symbols using three－dimensional shapes，such as blocks in the shapes of letters． Three－dimensional objects are more attractive to children than two－dimensional versions，stimulating more exploration and discussion（Evangelou，Dobbs－ Oates，Bagiati，Liang，\＆Choi，2010）．Moreover，children perform better on tasks that require them to discriminate letter shapes when the shapes are three－dimensional rather than two－dimensional（Fisher，1978，for Latin letters； Thornburg \＆Fisher，1970，for Latin and Kannaḍa letters）．But children need to learn to write using two－dimensional letters rather than three－dimensional letter blocks．Children in one study who practiced with three－dimensional Latin letters performed no better on two－dimensional letters than children who practiced with two－dimensional shapes（Thornburg \＆Fisher，1970）．The need to transfer from three－to two－dimensional shapes，evidently，outweighed the inherent advantages of the three－dimensional shapes．Moreover，it may be
harder for children to understand letters' symbolic functions if the letters are three-dimensional toys than if the letters are two-dimensional.

Another way to make letters' shapes more attractive and interesting to children, in addition to using three-dimensional shapes, is to turn letters into familiar creatures or objects. For example, in a program that is widely used in England to teach children about letters, the face of a cat is drawn in color within a black C shape and the letter is referred to as Clever Cat. In this mnemonic method, Clever Cat is the keyword that helps to link the letter shape and the sound. Some alphabet books use similar devices, as mentioned in $\mathbb{\int}$.2.2. Studies of such methods have typically focused on whether they help children learn letters' sounds, and we discuss this topic in chapter 9 . One study that examined the effects on the production of letter shapes found no benefit: 5 -year-olds were no better at producing a shape like V if they had learned it as a vase, with flowers drawn in, than if they had learned the unembellished shape (Ehri, Deffner, \& Wilce, 1984). For most symbols of most modern phonographic scripts, it's hard to find a familiar object whose shape naturally suggests the shape of the symbol but no other shape and whose name also suggests the sound. The shapes of familiar objects are more complex than the shapes of letters, and so thinking of «C» as a cat doesn’t tell a child whether the letter is shaped like the cat's ear, the cat's tail, or what. Moreover, the personification of letters may draw attention away from their sound-symbolizing function.

If educators and parents spend most of their time focusing on letters as two-dimensional and meaningless shapes, which is probably the best policy, which specific shapes should they use? One idea is to expose children to a single font or case rather than a mixture. In Finland, it has been customary to use all-uppercase letters in books for beginners, saving lowercase letters for later. This choice is based on the belief, which as mentioned in $₫ 8.2 .4$ appears to be well founded, that uppercase letters are easier than lowercase ones.

Some educators have suggested modifying traditional fonts for use with children. For example, visually highlighting the graphic components that are shared by the symbols of a script may help learners to distinguish writing from other types of marks and may speed learning of recurring graphic chunks. The ball-and-stick fonts that are sometimes used for the Latin alphabet do this by forming lowercase letters to the extent possible from circles and lines (58). However, this and some other sans serif fonts have the drawback that lowercase $\langle b\rangle$ and $\langle d\rangle$ are exact mirror images of each other, as are $\langle p\rangle$ and $\langle q\rangle$.
(58) abcdefghijklmnopqrstuvwxyz

Fonts that avoid exact mirror images may be preferable and have met with some success (McGinley \& O'Rourke, 1982). Another idea is to enhance certain features of letters in order to increase contrasts among letters. For example, the angle at the bottom of $\langle V\rangle$ and the curve at the bottom of $\langle U\rangle$ may be emphasized (Wolfe \& Cuvo, 1978). It has also been suggested that the vertical stems of such letter as «b» and «h» be deemphasized in order to draw children's attention
to these letters' more informative parts (Kolers, 1969). Some educators use color to emphasize critical portions of letters' shapes. In one study, visually highlighting the distinctions among letters in this way helped 5-6-year-old children more than explaining the distinctions verbally (Silver \& Rollins, 1973). However, using color to draw children's attention to important parts of letters could encourage them to attend to a feature that is normally irrelevant for writing. Another type of modification to traditional fonts, which is used in some texts for German beginners, involves putting a small curve below groups of letters that correspond to one speech sound, such as sch $/ \mathrm{S} /$.

The evidence we have reviewed suggests that direct instruction that includes feedback about correctness helps children to learn about the shapes of letters. Color, personification, or three-dimensional shapes may be useful in small doses in order to increase children's interest in and attention to letters. However, we suspect that extensive use of such devices may cause more problems than it solves. The research further suggests that children should be taught to write letters by hand before they learn to type because handwriting leads to better knowledge of letters' shapes. Children's handwriting will be worse when they write a story than when they write individual letters and words, a fact that advocates of discovery learning sometimes use to argue against direct instruction. But this doesn't mean that practice with isolated letters and words lacks value or causes harm. It means, instead, that children haven't developed the level of automaticity that they need to produce letters accurately and quickly while also doing the many other things that are required for writing. The solution isn't to forgo practice of the skill but to continue it.

### 8.5 Theories

The theories of orthographic knowledge and its development that were introduced in chapter 4 concur that knowledge of symbols' shapes is an important foundation stone for writing. However, most of the theories have little to say about how children acquire this knowledge. For example, current connectionist models that are intended to simulate the learning of spelling assume prior knowledge of letter shapes.

IMP $(\mathbb{\$} .6)$ sees the learning of symbol shapes and of the connections between shapes and linguistic units in terms of the same principles that govern other aspects of learning. In learning about shapes as graphic objects, children use many of the same skills that they use for other purposes. These include learning about patterns that hold across multiple instances and using those patterns to supplement memory for specific instances. Thus, children tend to perform better on shapes that are more typical of their writing system than on less typical shapes, and they sometimes misremember the less typical items as more typical. Children's previous experiences have accustomed them to tracking the frequencies of items and events, learning through language, and doing other things that are involved in the learning of letters' shapes,
but their previous experiences haven't accustomed them to attending to fine details of two-dimensional shape. People in English-speaking countries sometimes attribute the problems that some children have with spelling and reading to difficulties with mirror-image shapes such as those of «b> and «d>, and people in the Czech Republic sometimes attribute these problems to difficulties with diacritics. These explanations are too simple, but they have a grain of truth: Producing and perceiving the basic shapes of writing requires children to attend to certain things that they have often previously ignored.

### 8.6 Conclusions

Learning to produce writing involves learning to produce its basic shapes. These shapes have been influenced by many demands. The shapes within a system should be similar to one another, but they should contrast. They should have a degree of redundancy, but they should be quick and easy to produce. They should be similar to shapes that have been used in the past, attractive, and expressive. These demands sometime compete with one another. For example, similar shapes can be hard to tell apart, and shapes that worked well in the past may work less well when a language changes. The scripts in use today-the sets of shapes that children must learn-represent attempts to balance sometimes conflicting demands.

Children learn about the graphic properties of writing from an early age, learning both about its global characteristics, as described in chapter 5, and about the shapes of its basic symbols, as described in this chapter. As IMP predicts, children do this using many of the same skills that they use in other domains. However, learning about symbol shapes requires children to attend to certain visual details that they may have previously ignored, including leftright orientation in the case of certain scripts.

Given the many forces on systems of symbol shapes, it would be difficult to construct a writing system in which the shapes of symbols are related in a nonarbitrary way to their linguistic functions. In no writing system can a child consistently predict what the characters will look like based on more fundamental principles such as compositionality or iconicity. In the next chapter, we discuss another possible way of making the links between graphic symbols and their functions motivated rather than arbitrary. This solution, which has been adopted by many phonographic writing systems, is to give each symbol a name and to have the name serve as an intermediary between the shape of the symbol and the phonological units that it represents. We will see that children in many cultures learn the names of the symbols at an early age and use them as mediators in this way.

\section*{| chapter 9 | Letter Names |
| :--- | :--- |}

the basic symbols of writing have shapes, names, and linguistic functions. In this chapter, we focus on the names of the symbols. We begin the chapter by discussing the principles that underlie systems of letter names across languages ( $(9 \cdot 1)$. An understanding of these principles provides an important foundation stone for an understanding of how children learn the names and of what they do with this knowledge ( $(\mathbb{9} \cdot 2)$. We focus on the names of letters in alphabetic writing systems, mentioning syllabaries only briefly.

In later sections of the chapter, we discuss how children learn the names of letters. As we will see, children apply the skills that they use to learn words in general in their language to the learning of letter names. They often begin to learn about the formal or phonological properties of letter names before they know much about the sounds that the letters represent. Once children are familiar with letter names, they often use the names to help in learning the sounds.

Other sections of the chapter discuss the question of whether children should learn letter names at all $(\mathbb{\$} 9.4)$ and how the research on letter name learning fits with the theories of spelling development that were discussed in chapter $4(\$ 9.6)$. In addition, the chapter includes a short discussion of the names of auxiliary symbols of writing, such as diacritics ( $\$ 9 \cdot 5$ ).

### 9.1 Principles That Underlie Systems of Letter Names

Before discussing how children learn the names of letters, we must understand the characteristics of the names themselves. In the sections that follow, we discuss the principles that underlie systems of letter names across languages. Research hasn't yet been done with children in some of the writing systems that we discuss, but considering a broad range of writing systems is important for understanding the principles behind letter name systems.

## 9．1．1 Phonetic Iconicity

A spoken word is phonetically iconic if it resembles a sound that is associated with the word＇s referent（ $\mathbb{\int} 3.4$ ）．Phonetic iconicity sometimes occurs in words for sounds and in words for objects that make distinctive sounds．For example， the Japanese／ki／and the French／bip／，which contain close vowels，designate high－pitched sounds．We suspect that close vowels are more frequent in the words for high－pitched sounds than expected by chance，although we know of no system－ atic studies on this point．Another example of phonetic iconicity involves the words for sounds that animals make．In many languages，including English，Turkish， and Hungarian，the word for the sound a cow makes starts with $/ \mathrm{m} /$ ．Moreover， many languages have at least a few words for animals or for inanimate objects that make sounds that sound like the noise that the animal or object produces．For example，English uses cuckoo for a type of bird．

The name of a letter，like the word cuckoo，stands for something that is asso－ ciated with a sound．Indeed，the sound to which a letter corresponds is one of its most distinctive and important properties．It isn＇t surprising，therefore，that the names for the basic symbols of a phonographic writing system are pho－ netically iconic in most languages．In virtually all syllabic writing systems，that iconicity is perfect，in that each syllabogram is labeled with the linguistic unit that it represents．For example，き stands for $/ \mathrm{ki} /$ in one of the syllabaries used in Japan（Table 2．2），and speakers of this language call it／ki／．Similarly，in abu－ gidas（ $(\mathbb{2} 2.5)$ such as the writing systems for Kannaḍa，where a consonant letter like $\mathcal{f} k$ in its basic form is treated as being followed by an implicit vowel（／a／）， the name of a consonant letter is simply the sound of the syllable it spells，in this case，／ka／．Letter names aren＇t as perfectly iconic in other alphabetic writ－ ing systems，but they are still iconic．

The names of the letters of the Latin alphabet are shown in Table 9．1．The names used by the ancient Romans（the column labeled＂Latin＂）are the start－ ing point for the names of the letters in many languages that use the Latin script，although factors such as sound change alter some details of the pro－ nunciation．The letters that represent vowels had purely iconic names in Latin， in that their entire name is one of the sounds that the vowel makes．The con－ sonant letter names are partially iconic in that the name contains the sound the letter makes，here indicated by underlining．In order to make the name pronounceable，a vowel is added either before or after the consonant．There is a great deal of regularity in the system，in that almost all plosives form their name by adding／e：／after the consonant sound（〈B＞，〈C〉，〈D〉，〈G〉，〈P〉，〈T〉）， and most other sounds form their name by adding $/ \varepsilon /$ before the consonant sound（ $\langle\mathrm{F}\rangle,\langle\mathrm{L}\rangle,\langle\mathrm{M}\rangle,\langle\mathrm{N}\rangle,\langle\mathrm{R}\rangle,\langle\mathrm{S}\rangle,\langle\mathrm{X}\rangle$ ）．Even when an additional phoneme is added，the letter name is still similar to the unit of language that it symbolizes． It still has a high degree of phonetic iconicity．

The iconicity of letter names is apparent when the letter name subset of the vocabulary of a language is compared with other subsets，most of which are not iconic．Consider the names that languages use for geometric shapes．
table 9.1 Names of Letters of the Latin Script

| Letter | classical latin | US <br> ENGLISH | Finnish | French | brazilian portuguese | CAStilian SPANISH |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A | a: | $\underline{\text { e }}$ | a: | $\underline{\text { a }}$ | a | $\underline{\text { a }}$ |
| B | be: | $\underline{\text { bi }}$ | be: | be | be | $\underline{\text { be }}$ |
| C | ke: | si | se: | se | se | $\underline{\theta}$ |
| D | de: | di | de: | de | de | de |
| E | e: | $\underline{1}$ | e: | $\underline{\underline{\partial}}$ | $\underline{\varepsilon}$ | e |
| F | $\varepsilon \underline{1}$ | عf | æf | عf | 'عfi | efe |
| G | ge: | d ${ }^{\text {d }}$ | $\underline{\text { ge: }}$ | $\underline{3}$ | 3 C | $\underline{\text { xe }}$ |
| H | ha: | ets | ho: | as | a'ga | atse |
| I | i | $\underline{\text { ar }}$ | $\underline{i}$ | $\underline{1}$ | $\underline{1}$ | $\underline{1}$ |
| J | $N A^{\text {a }}$ | d ${ }^{\text {e }}$ | ji: | $\underline{3}{ }^{\text {i }}$ | '3̇te | xota |
| K | ka: | ke | ko: | ka | ka | ka |
| L | ع] | $\varepsilon]$ | æ] | ع1 | 'عli | ele |
| M | $\varepsilon \underline{m}$ | $\varepsilon \underline{m}$ | æm | $\varepsilon \underline{m}$ | 'êmi | eme |
| N | عn | $\varepsilon \underline{1}$ | æn | $\varepsilon \underline{1}$ | 'ẽni | ene |
| O | O: | O | $\underline{0}$ : | O | $\underline{\sim}$ | o |
| P | pe: | pi | pe: | $\underline{\text { pe }}$ | $\underline{\text { pe }}$ | pe |
| Q | ku: | kju | ku: | ky | $\underline{\text { ke }}$ | ku |
| R | عr | Qu | ær | £ $\underline{\square}$ | ' $\varepsilon \underline{\text { hi }}$ | ere |
| S | £s | £s | æડ | £s | 'Esi | ese |
| T | te: | ti | te: | te | te | te |
| U | NA ${ }^{\text {a }}$ | ju | $\underline{\text { u }}$ | $\underline{y}$ | $\underline{\text { u }}$ | $\underline{u}$ |
| V | $\underline{\text { u }}$ | vi | ve: | $\underline{\text { be }}$ | $\underline{\text { ve }}$ | ube |
| W | $N A^{\text {a }}$ | $\begin{array}{r} \text { 'dəbl } \\ \text { ju } \end{array}$ | kaksois ve: | dublove | 'dabliu | doble ube |
| X | عks | eks | æks | iks | Sis | ekis |
| Y | i: 'grarka | was | y: | $\underline{\text { i grek }}$ | 'ipsilõ | je |
| Z | 'ze:ta | zi | tset | zed | ze | $\underline{\theta}$ eta |

${ }^{\text {a }}$ Added to the alphabet in postclassical times.

Some of these describe the appearance of the shape, or began historically as such. Triangles are so named because they have three angles; sine waves look rather like waves in an ocean. Such names aren't typical of letters. There are some such names-the Finnish name for 〈W〉 (Table 9.1) is literally ‘double <v>', the English name for this letter is double u, and the word big may be used
in the English labels for uppercase letters．However，shape－based names may get replaced over time，as when $i$ long＇long $i$＇and $i$ à queue＇$i$ with a tail＇，the earlier French names for $\langle>$ ，were replaced with $/ 3 \mathrm{i} /$ ．

The names of certain other objects tell where the object came from or where it is currently found．Adirondack chairs，one presumes from the name，were invented and manufactured in the Adirondack Mountains．Names of this sort are uncommon for letters．The Latin and French names of 〈y＞（Table 9．1），which translate as＇Greek «i＞’，indicate that the letter was copied from the Greek alpha－ bet to spell Greek loanwords．Another example（shown in Table 9．2，letter 13）is the Hebrew name of $\square$ ，／mem so＇fit／＇final mem＇．This name indicates where the letter is found：It is a form of the letter／mem／that appears at the ends of words．These sorts of letter names are uncommon across languages，however．

The name of a letter usually reflects not its shape or its origin but its func－ tion：a sound that the letter symbolizes．Like labels such as air conditioner and rolling pin，the name of a letter usually suggests what it does．A few letter names do this by describing the characteristics of the sound for which the letter stands，as with the Turkish $\gamma u m u s ̧ a k ~ g e ~ ' s o f t ~ g ' ~ f o r ~ 〈 \breve{g}\rangle$ ，which used to represent a velar approximant sound similar to／w／but is now silent．When a letter represents a specific sound，however，its name doesn＇t usually attempt to describe the sound．Rather，the name is the sound or includes the sound．

When a letter can symbolize more than one phoneme，just one of these is typi－ cally coded in the letter＇s name．For example，the English name of 〈I＞encodes the ／aI／pronunciation as in item rather than the／I／pronunciation as in Tim．A major reason for this is that naming the letter／ $\mathrm{I} /$ would make a word that deviates from the sound patterns of English words：Words can＇t end in a stressed／ $\mathrm{I} /$ ．As we discuss in $\mathbb{\$ 9 . 1 . 2 \text { ，phonological legality is an important constraint on letter names．}}$ The English names of «C〉 and «G〉 include sounds that are associated with the let－ ter（as in cent and gent）but not the more frequent sounds $/ \mathrm{k} /$ as in $c a b$ and $/ \mathrm{g} /$ as in gab（Table 9．1）．The inclusion of more than one of a letter＇s sounds in its name would make letter names longer，and short names have the advantage of economy． The conventional names of Korean consonant letters are longer than the letter names of many other languages in that they include two consonants－the letter＇s pronunciation in both initial and final positions of words－together with a vowel． For example，／mium／is the name of the letter $\square$ ，which symbolizes $/ \mathrm{m} /$ ，and ／siot／is the name of the letter 人，which represents／s／at the beginning of a syl－ lable and $/ \mathrm{t}$／at the end．The extra information about the letters＇sounds evidently compensates for the loss in economy．

Most commonly，the letter＇s sound（phone in Greek）is at the head（acron） or beginning of the letter name．That is，the letter name is acrophonic．Some languages have only acrophonic letter names，and others have some phoneti－ cally iconic but nonacrophonic names as well．In the latter，the sound may appear at the end of the letter name，as with the English name of $\langle\mathrm{M}\rangle, / \mathrm{\varepsilon m} /$ ，or in the middle of the name，as with the Portuguese name of $\langle\mathrm{L}\rangle$ ，／＇$\varepsilon$ li／．English and Portuguese have more letter names with the sound at the beginning than with the sound in the middle or at the end，and the same is true in most other
languages．There are some languages in which all letter names have the pho－ neme at the end，though．Tifinagh，a script used for Berber languages espe－ cially in Morocco，has letter names such as／jab／for $\Theta / b /$ and／jad／for $\wedge / d /$ ．

Iconicity is such an important property of letter names that it is often introduced when lacking．An example comes from Portuguese，where 〈X＞ typically has the value $/ \int /$ ．The traditional name of $\langle X\rangle$ as inherited from Latin（Table 9．1）would have lacked iconicity in Portuguese and therefore was replaced by $/ \mathrm{Sis} /$ ．As another example，the name of $\langle\mathrm{H}\rangle$ has changed in some parts of the English－speaking world from／et $\widehat{\delta} /$ to the longer but more iconic $/ h e \bar{t} /$ ．One of us，unaware at the time that some Australians say／het $\widetilde{\mathrm{j}} /$ ，gave〈 H 〉 as an example of a noniconic letter name when speaking to a group of teachers and researchers in Australia．Several members of the audience later mentioned，in a rather embarrassed way，that some Australians say／het $\overline{\mathrm{S}} /$ ． This pronunciation is spreading but，like many innovations，is still stigmatized in some countries．This and most other changes in the pronunciations of let－ ter names that occur over time reflect the will of the people rather than the intervention of an outside body．From time to time，though，there have been explicit proposals for the reform of letter names in order to make them more iconic．In the 17th century，for example，it was suggested that English／et $\overline{5} /$ should be replaced with／hi／and／＇dəblju／with／wi／to make them easier to learn（Weinstock，1995）．Littré（1891）gave in addition to the traditional French names as listed in our Table 9.1 a＂modern＂pronunciation of consonant letter names，which consists of the consonant sound followed by the neutral vowel $/ \partial /$ ，so that $\langle\mathrm{F}\rangle$ would be named／fə／．Although those new names appear never to have caught on in French（Grevisse，1964，p．47），Albanian uses exactly that system．Turkish is very similar，except that it uses／e／instead of／／／，which is lacking in its vowel inventory．

The Latin system of naming letters replaced an early letter naming system inherited from the Phoenicians．In that system，each letter was given a name whose initial phoneme was the sound made by that letter．For example，the let－ ter that spelled／d／was named／＇daltu／＇door＇．The initial phonemes of words are more salient and accessible than the later ones（Treiman \＆Zukowski，1991； Walley，Smith，\＆Jusczyk，1986），and so it is no accident that these Phoenician letter names had the sound at the beginning．Furthermore，it appears that some or all of the letter shapes were meant to be pictures of the object that has the same name as the letter．For example，$\triangleleft$ ，the symbol named／＇daltu／， apparently looks like some sort of door．When the Phoenician alphabet was borrowed for use with different languages，the Phoenician names were usually borrowed as well－not translated，but borrowed as a foreign word，with only minimal changes to accommodate to the sound system of the new language． This is an example of conservatism，the implications of which for letter names
 $(\Delta)$ ，in Hebrew it became／＇daled／（ 7 ），and in Arabic it became／da：l／（ $\Delta$ ）．（The modern colloquial names of the Hebrew letters are given in Table $\mathbb{\int}$ 9．2．）In the languages that use the Phoenician names，they don＇t necessarily have any
table 9.2 Colloquial Names of Letters in Modern Hebrew

| order | Letter | name |
| :---: | :---: | :---: |
| 1 | $\aleph$ | /'alef/ |
| 2 | ב | /bet/ |
| 3 | $\lambda$ | /'gimel/ |
| 4 | T | /'daled/ |
| 5 | ה | /hej/ |
| 6 | 1 | /vav/ |
| 7 | i | /'zain/ |
| 8 | $\pi$ | / $\underline{\chi e t}$ / $^{\text {ct }}$ |
| 9 | $\bigcirc$ | /tet/ |
| 10 | , | /jud/ |
| 11 | כ | /kaf/ |
|  | 7 | /kaf so'fit/ |
| 12 | ל | /'lamed/ |
| 13 | $\square$ | /mem/ |
|  | $\square$ | /mem so'fit/ |
| 14 | 1 | /nun/ |
|  | 1 | /nun so'fit/ |
| 15 | 0 | /'same $/$ |
| 16 | y | /'ain/ |
| 17 | - | /pej/ |
|  | ๆ | /pej so'fit/ |
| 18 | 3 | /'tsādik/ |
|  | $r$ | /'tsāadik so'fit/ |
| 19 | $\bigcirc$ | /kuf/ |
| 20 | 7 | /rej j/ |
| 21 | $\cdots$ | / Sin/ $^{\text {in }}$ |
| 22 | ת | /taf/ |

meaning as words naming objects. For example, /délta/ doesn’t mean 'door’ in Greek. Although it may seem a loss that the borrowed letter names couldn't identify the letter shapes for foreigners who borrowed the script, in Phoenician times the letter shapes were already so simple as to largely be unidentifiable as pictures. That became even more true as the letter shapes evolved. Crucially, however, the letter names in these scripts are still acrophonically iconic, in that the initial phonemes still match the sounds represented by the letters.

Although some of the iconicity in the letter names of modern languages such as Arabic, Greek, and Hebrew can be traced to the properties of the ancient Phoenician script, shared history doesn't fully explain the iconicity that exists in many letter name systems. For example, Korean is historically unrelated to the systems just mentioned but also has iconic letter names. The Latin script thoroughly revamped its original Phoenician letter naming system to strip off most of the noniconic sounds. More recently languages such as Albanian, as previously mentioned, revamped the Latin system. The specific type of iconicity that exists in most systems, acrophonicity, isn't just a historical accident either. As mentioned earlier, it reflects the special status of word-initial phonemes. Letter name systems are iconic not just by historical accident but because iconicity benefits learning and memory by making associations motivated rather than arbitrary. Iconicity isn't usually feasible in spoken languages, but letter names are one case in which it is feasible. In this case, it turns out to be very common.

### 9.1.2 Legality

The names of a writing system's symbols are part of the vocabulary of the corresponding language. Thus, they must follow the same phonotactic patterns that other words of the language follow. Some phonotactic patterns in a language have no exceptions. For example, English words never end with /h/ and never consist of single consonants. This means that $/ \mathrm{\varepsilon h} /$ and /s/ wouldn't be phonotactically legal letter names. Other phonotactic patterns are probabilistic: Some phonemes and phoneme sequences occur more often in words than others. Thus, when a letter name contains sounds in addition to the one that the letter represents, these are often common sounds that appear in common contexts. The legality principle makes letter names of a piece, at a broad level, with other words of the language.

In Phoenician, letter names were phonotactically legal because they were drawn from words that already existed in the language. In languages that borrowed the Phoenician letter names along with their shapes, changes were made as needed to conform to the sound inventory of the borrowing language. For example, the name / $\mathrm{t}^{\mathrm{f}} \mathrm{e}$ :tu/ was borrowed into Greek as $/ \mathrm{t}^{\mathrm{h}} \mathrm{E} \hat{\mathrm{t}} \mathrm{ta}$ /, because Greek didn’t have Phoenician's pharyngealized consonants. The sound represented by the symbol also tracked the letter name change, so that the letter name system was still acrophonic: $\Theta / \mathrm{t}^{\mathrm{h}} \hat{\varepsilon} \mathrm{ta}$ / represented the $/ \mathrm{t}^{\mathrm{h}} /$ sound in classical Greek. In like manner, the Phoenician letter name /Ralpu/ was borrowed into Greek as /álp ${ }^{\mathrm{h}} \mathrm{a}$ /. The initial glottal stop was omitted because it wasn't a phoneme in Greek. The loss of non-Greek consonants from the beginning of this and similar names explains how Greek ended up with letters that spell vowels, which were lacking in the Phoenician abjad-style alphabet ( $\mathbb{\$ 2 . 5}$ ). By the acrophonic principle, /álp ${ }^{\mathrm{h}} \mathrm{a}$ / starts with $/ \mathrm{a} /$, and so it spells the vowel sound $/ \mathrm{a} /$.

In Latin and several other languages that borrowed the Latin script, a phonological rule requires vowels at the end of monosyllabic words to be long.

This explains why the Latin names for the vowel letters are all long（／a：／， ／e：／，etc．）even though the more common value of those letters is the short vowel sound．It also explains why the consonant letter names all end in long ／e：／．A very similar rule is discernible in English．A few centuries ago，several vowels such as $/ æ /, / \varepsilon /$ ，and $/ \mathrm{I} /$ were always phonetically short．English didn＇t allow short vowels to occur at the end of monosyllabic words．Even though nowadays it isn＇t phonetically accurate to say that these vowels are always short，the rule preventing them from occurring at the end of monosyllables still holds．Consequently，if the letter 〈A $\rangle$ were to be named／æ／after its more common value，that name would be phonotactically illegal．

## 9．1．3 Similarity

Although letter names are like other words of the language in following the phonotactic constraints，they are more similar to one another than a random subset of words of a language would be．Thus，just as the verbs of a language may have some different phonological properties than the nouns（Monaghan et al．，2007），so the letter names may have some differ－ ent phonological properties than other words．Across languages，the simi－ larity among letter names ranges from marked to subtle．As compared to other languages，English is intermediate in the degree of similarity of its letter names．Most English letter names contain either one or two pho－ nemes．The majority of the two－phoneme names consist of a consonant followed by $/ \mathrm{i}$／or else $/ \varepsilon /$ followed by a consonant（Table 9．1）．The conso－ nant in the first type of letter name is typically a plosive，as for $\langle\mathrm{B}\rangle,\langle\mathrm{D}\rangle,\langle\mathrm{P}\rangle$ ， and 〈 T$\rangle$ ，and the consonant in the second type of letter name is typically a sustained consonant－a sound that can be held—as for 〈F»，〈L〉，〈M〉，〈N〉， ＜S＞．Not all English letter names follow these phonotactic patterns－＜W＞＇s name has three syllables，«V＞＇s name is a consonant－initial letter name with a sustained rather than a plosive consonant，and «R＞＇s name begins with ／a／．However，the patterns hold in many cases，making the names of letters more similar to one another than the names of fish or vegetables．Dr．Seuss （1955）played with this aspect of language in his book，On Beyond Zebra， which introduced such letters as thnad and fuddle（for their shapes，see example（14）in $\left.\int 8.1 .5\right)$ ．These letter names don＇t follow the phonological patterns that are typical of English letter names．Some of them，like thnad， don＇t even follow the phonological patterns that are typical of English words．This is part of the reason that children and parents find Dr．Seuss＇s letters so funny．

In many languages，the names of the letters are even more similar to one another than they are in English．The languages that have revamped the let－ ter naming system，such as Turkish and Albanian，have often opted to make all letter names consist solely of the letter sound itself，with a vowel added to consonant letter names to make them pronounceable．Tifinagh consonant let－ ter names start with／ja／，followed by the sound of the consonant．Not only are
all the letter names unusually short words in these systems，but the consonant names are all unusually similar in that the same helping vowel is typically used for all consonants in the language＇s alphabet．

The letter names of languages that borrowed the Phoenician letter names， including Hebrew and Greek，are more dissimilar phonologically．Still，the letter names in these systems have certain phonological commonalities．The disyllabic names of Hebrew all have stress on the first syllable，for example， and several have a／＇ $\mathrm{CaCeC} /$ pattern（where C stands for a consonant）that is rare in other Hebrew words（Table 9．2，letters 1，4，12，and 15）．

The phonological similarity among letter names results，in part，from the fact that letter names are usually phonetically iconic．The name of a letter is similar to the sound it symbolizes in that the name includes that sound plus， in many cases，a small number of other sounds．If this is true for many letter names in a language，the names will be phonologically similar．If iconicity were the sole consideration，different sounds could be added for different letter names．But the sound is often the same，as in the English／bi／，／si／，and／di／ and the Korean／mium／and／nium／．The fact that the same helping vowel is added across a series of letter names increases the similarities among the names，and it suggests that similarity influences letter name systems above and beyond iconicity．The fact that the same helping vowel is added across a series of letter names may also make the iconicity easier for children to use． For example，one pulls／e／off the names of Turkish consonants in order to retrieve the sound．

When letter names change over time，these changes may be driven by sim－ ilarity．For example，the change in 〈Z’s name from／zed／to／zi／that has occurred in the United States and some other parts of the English－speaking world makes 〈Z＞＇s name more similar to the other letter names of English． A drive toward similarity must also be behind the complete revamping of the letter name system in languages such as Albanian and Turkish，where all consonant names end with the same vowel，replacing the older system where some letters such as $\langle\mathrm{F}\rangle$ and «M» started with a vowel and others such as $\langle\mathrm{B}$ 〉 and 〈T〉 ended with a vowel．

The phonological commonalities among letter names set them off from other subsets of the vocabulary．Consider the set of number names．Latin let－ ters and Arabic numbers look rather similar to one another（\＄8．2．1），and they are often mixed in texts．For example，the first symbol in the license plate 5KIDZ looks rather similar to the following symbols，even though it is a number and the other symbols are letters．Fortunately for children，the names of letters and numbers have different phonological properties in many languages．In English，names that consist of a single consonant followed by／i／or else pre－ ceded by $/ \varepsilon /$ are common for letters but nonexistent for numbers．Turkish letter names are either a single vowel or else a consonant followed by／e／． Turkish number names have a variety of phonological structures，but never these．The differences in the outer forms of letters and numbers correlate with deeper distinctions between them．

Phonology also cues some important distinctions within the class of letters. In English and many other languages, letters with names that contain two or more phonemes generally symbolize consonants, whereas letters with one-phoneme names symbolize vowels. These differences reflect the pressure for letter names to be both iconic and phonotactically legal. Usually one or more phonemes must be added to a consonant to make it a legal syllable; nothing need be added to a vowel. English-speaking children could use these phonological differences to place letters with names like /bi/, /vi/, and /pi/ in one category and those with names like /o/, /az/, and /e/ in another category. The shapes of the two sets of symbols don't differ much, but the names do.

### 9.1.4 Contrast

The letter names of a language, like other words, should contrast with one another. Contrast decreases the potential for confusions in perception, memory, and production. Iconicity and similarity, although beneficial in many ways, tend to decrease contrast. It is easy to mishear $\langle\mathrm{M}\rangle$ as $\langle\mathrm{N}\rangle$ whether one is using the English (/عm/, /عn/), Turkish (/me/,/ne/), Korean (/mium/, /niun/), or Portuguese (/'ẽmi/, /'ẽni/) letter names. Pilots and air traffic controllers, who depend on accurate spoken-letter understanding to distinguish the call letters of airplanes, have developed alternate sets of letter names that are less economical but more contrastive. The International Civil Aviation Organization calls 〈M〉 Mike and < N$\rangle$ November, for example. For similar reasons, people who aren't pilots or air traffic controllers sometimes use words to clarify which letters they mean when they must say letter names in a noisy room or over a poor telephone connection. Confusions among letter names are less likely in languages such as Hebrew and Greek, where the names are generally less phonologically similar to one another. When spelling words aloud, speakers of these languages rarely need to clarify which letter they mean by giving a word that starts with the letter. The fact that many languages tolerate confusable letter names suggests that iconicity and similarity are more important for letter name systems than a high degree of contrast.

### 9.1.5 Economy

Words should be economical to produce, and letter names should, too. Indeed, letter names are usually shorter than the average word of the language to which they belong. For example, in English the average letter name is 2.1 phonemes long, and in Portuguese (omitting the rare letters $\langle\mathrm{K}\rangle,\langle\mathrm{W}\rangle$, and $\langle\mathrm{Y}\rangle$ ) the average letter name is 2.2 phonemes long. In contrast, in our database of words found in texts designed for preschoolers and first-graders, words average 4.8 phonemes in English and 5.4 phonemes in Portuguese. Thus letter names are less than half the length of a typical word. The shortness of letter names may reflect the fact that iconicity is easier to use if a minimal number of phonemes is added to the sound symbolized by letter. However, the existence and durability of letter name systems such as those of Hebrew and Greek, in which a
number of letter names are more than just a few phonemes long, shows that other factors may outweigh economy in letter name systems. Indeed, some changes to letter names make the names longer but more iconic. /he $\widehat{t}$ / is longer than /et $\widehat{\jmath} /$, for example, but it may be a better name in that it includes the letter's sound.

### 9.1.6 Conservatism

The phonological forms of words, including words for letters, change over time. Testifying to the force of conservatism, the changes are gradual rather than drastic. Thus, the names of letters in the many modern descendants of Latin are similar to those that were used in Latin. However, we suspect that the names of letters change somewhat more quickly than other words do, that is, that letter names are somewhat less conservative than other words. This is because letter names aren't usually written phonetically. Because people don't usually write aitch, for example, they may be less reluctant to add an initial /h/ than they would be if they frequently spelled the letter name. Indeed, as we discuss in chapter 13 , there is some evidence that writing things down slows the pace of language change.

### 9.1.7 Other Principles

In chapter 8, we discussed the roles of beauty ( $\$ 8.1 .3$ ) and expressiveness ( $\$ 8.1 .4$ ) in systems of letter shapes. These aren't important considerations for letter names, probably because people hear through speech more than they look through writing. Thus, people don't choose letter names because of their attractive sounds in the way that they choose letter shapes because of their attractive looks. Nor do people pronounce letter names in different ways to express their feelings in the way that they choose certain fonts to express certain feelings. These considerations mean that there is less variation among instances of a letter name than among instances of a letter shape. Different speakers of a language say the same letter name differently depending on the pitch of their voice, their dialect, and so on, but the variations in how they pronounce letter names aren't larger than the variations in how they pronounce other words. Some cultures do have different sets of letter names, as with the standard and informal letter names that are used in some Arabic-speaking communities (Levin, Saiegh-Haddad, Hende, \& Ziv, 2008). However, these variations are small compared to the variations among fonts and styles that are seen with letter shapes.

Redundancy is beneficial for many systems, including letter shapes ( $\$ 8.1 .7$ ). Its value derives in part from the protection that it offers if one component malfunctions. Spoken words are redundant in that they often contrast in more than one phoneme. Letter names usually have less redundancy than other words of the language. For example, letter names such as the /be/, /de/, and $/ \mathrm{fe}$ / of Turkish contrast with one another in only one phoneme. Adding a different phoneme to the end of each letter name would increase redundancy
but would make the names less economical and their iconicity less noticeable. The relatively long letter names of Hebrew (Table 9.2) are more redundant and elaborate than the letter names of Turkish or English, but systems such as that of Hebrew aren't very common. The relative lack of redundancy in letter name systems probably reflects the importance of economy and iconicity in letter name systems.

### 9.1.8 Summary of Principles That Underlie Systems of Letter Names

The systems of letter names in use today reflect the combined influences of the factors we have discussed: iconicity, legality, similarity, economy, contrast, and conservatism. Iconicity is a major consideration, with most letter names in most languages being no longer than they need to be in order to be a legal word of the language that includes, and ideally begins with, the sound that the letter represents. The lack of redundancy and low degree of contrast in the letter names of many languages are tolerated because the advantages of iconicity outweigh the disadvantages. A rose by any other name might smell as sweet, but a name that didn't include /b/ would be a poor label for the letter that symbolizes this sound.

### 9.2 Learning the Phonological Forms of Letter Names

Having discussed the nature of what children must learn, in the case of letter name systems, we turn now to the question of how children learn it. Children in many literate societies hear the names of letters from an early age, just as they hear other words of their language. Some of this talk is directed at them, when a parent talks with a child about the letters on the license plate of a toy car. Some of this talk is directed at other people, as when a child hears his mother saying that her name starts "/ti ar i aı/—not /ai i/." As we discussed in chapter 3, children are built to learn about speech, both about the phonological forms of words and about the links between these forms and their referents. Children apply these skills to the learning of letter names, as to the learning of other words.

Children learn about the phonological forms of some words before they learn the words' referents. This may be particularly true for letter names, in part because adults sometimes say the names when no letter shapes are present (Robins et al., 2012). These conditions aren't conducive to linking words with their referents. Further promoting early learning of letter names' phonological forms, those forms are in most languages rather simple. As we have discussed, they are usually monosyllabic, in many languages just one or two phonemes long. They often contain relatively frequent phonemes and phoneme sequences. These properties, as mentioned in chapter 3, help children to learn phonological forms.

Frequency of exposure plays an important role in the learning of letter names, as it does in the learning of other words (Schwartz \& Terrell, 1983). Evidence presented in $\llbracket 8.2 .3$ shows that the more often an association between a letter shape and a name has been encountered, the better children tend to perform in letter naming tasks. Further testifying to the importance of frequency, children who mislabel a letter are more likely to use a common letter name, such as /ti/ for English-speaking children, than a less common name, such as /kju/ (Treiman, Kessler, \& Pollo, 2006; Treiman, Levin, \& Kessler, 2007). For young children, as mentioned in $\llbracket 8.2 .3$, frequency is partly an individual matter. Zoe hears /zi/ when her parents talk to her about the letters in her name or point out this letter on signs. The frequency of /zi/ is higher for her than it is for Babe. Such child-specific factors mean that young learners of alphabetic writing systems are better at naming the letters from their own name, especially the first letter, than at naming other letters (e.g., Treiman et al., 2006; Treiman, Levin et al., 2007). Between child ages of 1 and 5, the frequency with which parents talk about letters in everyday conversations becomes more closely tied to the frequency of the letters in the language in general (Robins et al., 2013). Likewise, the frequency with which children talk about particular letters and their performance in letter naming tasks become increasingly tied to the frequency of the letters in the language (Bouchière, Ponce, \& Foulin, 2010; Robins et al., 2013).

Letter names in most languages are similar to one another, as we have discussed, and children implicitly learn about these phonological similarities. Consider some studies in which US children with a mean age of about 4 years and 8 months were introduced to a puppet who, it was explained, didn't know very much about letters (Treiman, Tincoff, \& Richmond-Welty, 1997). The puppet was made to say various syllables, and the children were asked to indicate which ones were letter names. The children were more likely to accept syllables that began with a consonant or consonant cluster followed by /i/ (e.g., /fi/, /kli/) than to accept syllables with these same consonants followed by other vowels (e.g., /fo/, /klau/) or syllables that began with /i/ (e.g., /if/). Children were also more likely to accept syllables that began with $/ \varepsilon /$, which appears at the beginning of some English letter names, than syllables that began with vowels that rarely or never appear at the beginnings of English letter names. Evidently, at least some US 4 -year-olds have implicitly learned about the phonotactic properties that set letter names apart from other words.

The fact that children often hear letter names in combination with other letter names probably helps children to notice their phonological similarities. According to one study, in fact, almost half of the letter names that children hear from their parents are said in a sequence together with other letter names (Robins et al., 2013). We suspect that children are more likely to hear strings of letter names than to hear strings of animal names, for example.

The phonological similarities among letter names may help children to learn that letters form a class; that they differ, for example, from numbers. The phonological similarities among letter names may offer another benefit
as well: They may help a child to reconstruct the name of a letter if the phonological representation that the child possesses is incomplete. If the identity of the vowel in the name of $\langle\mathrm{B}\rangle$ has faded from memory, for example, an
English-speaking child who knows that /i/ often appears in the letter names of English could infer the correct name. A Turkish-speaking child, based on the properties of Turkish letter names, might infer that the vowel is /e/.

The phonological similarities among letter names, although beneficial in some ways, appear to cause some problems in linking specific names to specific shapes. Children of about 4 and 5 years of age will sometimes call a letter by another letter name that is phonologically similar to the correct one, especially if the competitor's shape is also similar (Treiman et al., 2006). When shown a letter and asked to name it, children make more errors if the letter's name is phonologically similar to the names of many other letters (as with /vi/ for English) than if the letter's name is more distinctive (Treiman \& Kessler, 2003). Indeed, phonological similarity can harm even adults. An educated adult wouldn’t mislabel < V > as /bi/, but she might misremember /vi/ as /bi/ after a delay (R. Conrad, 1964).

In some cases, a phonological form is homophonous: It is both a letter name and another word. For example, young children may hear /ti/ as a type of drink (tea) as well as a letter name. In some situations, children find it difficult to learn a second meaning for a phonological form for which they already have one meaning (Backschneider, Gelman, Martinez, \& Kowieski, 1999). This doesn't appear to be the case for letter names, however. Other things being equal, English-speaking children make no more errors in letter-naming tasks with homophonous letters such as $\langle\mathrm{T}\rangle$ and « B$\rangle$ than with letters such as $\langle\mathrm{F}\rangle$ and <Z> (Treiman et al., 2006). The fact that children hear letter names like that of 〈 T$\rangle$ in rather different contexts than words like tea probably minimizes any potential problems.

As we discussed in $\int 8.2$, the learning of letter shapes presents children with some problems they haven't previously encountered. Specifically, children must attend to fine details of two-dimensional shape with letters, details they sometimes ignore with other objects. The learning of letter names as phonological forms doesn't present children with many new problems. The names of letters are more similar to one another than many other words, harder to discriminate auditorily, but children have faced this issue before with similar-sounding words like big and pig. Learning of words' phonological forms begins in infancy, and children apply the skills that they already possess in order to learn the phonological forms of letters.

### 9.3 Do Children Benefit From the Phonetic Iconicity of Letter Names?

Learning about a letter name, like learning about any other word of a language, doesn't end with learning the phonological form. Knowledge of the
phonological form isn＇t very useful until children have linked that form to its referent．The link between the phonological form of a letter name and the letter＇s shape is usually arbitrary．One can＇t predict that the English phono－ logical form $/ \mathrm{\varepsilon m} /$ is associated with «M〉 as opposed to 〈P〉，just as one can’t predict that／kæt／is linked with cats as opposed to potatoes．However，the link between the phonological form of a letter name and the sound that the letter symbolizes isn＇t usually arbitrary．Given the phonetic iconicity of letter name systems，one can predict that the letter that has the name $/ \mathrm{Em} /$ stands for $/ \mathrm{m} /$ as opposed to $/ \mathrm{p} /$ ．One wouldn＇t expect phonetic iconicity to be so com－ mon across letter name systems if people didn＇t use it．Indeed，the research to which we now turn shows that children take advantage of the iconicity of letter names from an early age．

One source of evidence that children benefit from the iconicity of letter names comes from studies examining their knowledge about the sounds that are associated with letters．In such studies，children are asked to say the sound to which a visually presented letter corresponds—／s／or／sə／for «S〉，／bə／for «B»，and so on．By around their fourth birthday，provided that they know the let－ ter names，North American children＇s performance on this task is influenced by whether a letter＇s sound appears in its name and，if so，its position．Children tend to perform best on letters whose sounds appear at the beginnings of the letters＇names．For example，children are relatively good at saying that＜V＞ makes the sound／və／．Performance is somewhat poorer on letters such as «L»， whose sounds appear at the ends of their names．Letters such as 〈W W ，whose sounds don＇t appear in their names，tend to be hardest of all（M．A．Evans， Bell，Shaw，Moretti，\＆Page，2006；Treiman，Tincoff，Rodriguez，Mouzaki，\＆ Francis，1998）．These differences don＇t appear to reflect different levels of famil－ iarity with the letters＇names or shapes，because children＇s ability to provide the name of letters doesn＇t differ systematically for letters in the name－initial， name－final，and not－in－name categories（Treiman et al．，1998）．Nor are the let－ ters in the latter categories more likely to symbolize difficult－to－pronounce phonemes（Treiman，Pennington，Shriberg，\＆Boada，2008）．The evidence just cited comes from North American learners of English，but there is some evidence that learners of French also perform better on acrophonic letters than other letters on tasks that require knowledge of letters＇sounds（Ecalle，2004）．

A second source of evidence that children benefit from the phonetic ico－ nicity of letter names comes from experiments in which children are taught the sounds that letters represent，as done in classrooms that use phonics instruction．In one study（Treiman et al．，1998），US children with a mean age of 4 years and 11 months who knew the name but not the sound of a letter such as $\langle\mathrm{V}\rangle$ learned the sound relatively quickly，／v／being in the salient initial position of the letter＇s name．Children learned letter sounds more slowly for letters like $\langle\mathrm{L}\rangle$ ，where the sound $/ \mathrm{l} /$ is at the end of the letter＇s name，and even more slowly for letters like $\langle\mathrm{H}\rangle$ ，where the sound／h／isn＇t in their pronuncia－ tions of the letter＇s name．In another study，Brazilian 4－year－olds who had been taught letter names showed an advantage in letter－sound learning for letters
like $\langle\mathrm{B}\rangle$ ，where the sound appears at the beginning of the name（／be／），over letters like $<\mathrm{L}$ ，where the sound appears in the middle of the name（／＇eli／） （Cardoso－Martins，Mesquita，\＆Ehri，2011）．

Additional evidence that children who know the names of letters use this knowledge to make inferences about the letters＇sounds comes from exam－ ining the sounds that children associate with letters that correspond to more than one sound．In English，〈C〉 most often symbolizes $/ \mathrm{k} /$ ，as in cat，but it can also stand for $/ \mathrm{s} /$ ，as in cell．The letter «G＞can stand for $/ \mathrm{g} /$（get）or $/ \overline{\mathrm{d} 3} /$ （gel），with more words exemplifying the former correspondence than the lat－ ter．When asked to provide the sounds of «C〉 and «G〉，US children of around 5 years of age produce responses with $/ \mathrm{s} /$ and $/ \overline{\mathrm{d} 3} /$ much more often than responses with $/ \mathrm{k} /$ and $/ \mathrm{g} /$ ．These children seem to prefer $/ \mathrm{s} /$ and $/ \widehat{\mathrm{d}_{3}} /$ because these are the first phonemes of the letters＇names（Ellefson，Treiman， \＆Kessler，2009）．Further evidence for the influence of letter names comes from studies in which Israeli 4 －to 6 －year－olds see an isolated letter such as ל， named／＇lamed／，and are asked to supply its sound．These children often say ／la／，using the first two phonemes from the letter＇s name．They prefer the vowel／e／with a letter like $u$ ，named／tet／，saying／te／more often than／ta／or ／ti／（Levin，Shatil－Carmon，\＆Asif－Rave，2006；Treiman，Levin，\＆Kessler，2011）．

The errors that children make in giving sounds for letters provide further evidence that children who are familiar with letters＇names use them to as clues to the phonemes the letters represent（Ellefson et al．，2009；Treiman， Tincoff，\＆Richmond－Welty，1996；Treiman，Weatherston，\＆Berch，1994）．For example，US 4－to 6 －year－olds sometimes say that «Y＞makes the sound／wə／． The presence of／w／at the beginning of the letter name／waI／evidently sug－ gests that 〈Y〉 stands for／wə／，just as 〈J〉 stands for the first phoneme of its name，$/ \overline{\mathrm{d}_{3}} /$ ．Similarly，US youngsters sometimes say that＜W＞makes the sound $/ \mathrm{d} \partial /$ ，the phoneme at the beginning of 〈W’＇s name，and that 〈M〉 makes the sound $/ \varepsilon /$ ．The US children in these studies made errors such as saying that〈 Y$\rangle$ makes the sound／wə／despite having been taught otherwise in phonics instruction．Another study looked at children in New Zealand who were taught using whole－language methods（ $(\mathbb{1} .3 .1)$ ．These children were familiar with let－ ter names but had received no explicit teaching about the sounds of isolated letters．When asked to provide letters＇sounds，these children nonetheless pro－ duced some conventionally correct responses such as／və／for 〈V〉（Thompson， Fletcher－Flinn，\＆Cottrell，1999）．Such correct responses were more likely for letters with acrophonic names，such as＜V〉，than for other letters．The New Zealand children，like US children，sometimes made errors such as saying that〈 Y 〉 made the sound／wə／or that 〈W〉 made the sound／də／．

The findings suggest that children＇s errors in providing the sounds of let－ ters，odd though some of them might seem at first，sometimes reflect the chil－ dren＇s knowledge of the letters＇names．The results further suggest that，when teaching children about the sounds of letters，it may not be wise to spend the same amount of time on each letter，as in the letter of the week approach．For children who are already familiar with letters＇names，more time should be
devoted to sounds that don＇t fit well with that knowledge and that are thus dif－ ficult to learn，such as the link between $/ \mathrm{h} /$ and 〈H〉．Easier correspondences， such as that between $/ \mathrm{v} /$ and $\langle\mathrm{V}\rangle$ ，need less time．

Learning a label such as $/ \mathrm{vi}$／for $\langle\mathrm{V}\rangle$ and using that label to help learn that $\langle\mathrm{V}\rangle$ symbolizes／ $\mathrm{v} /$ is in some ways similar to the Phoenician system men－ tioned in $\S 9.1 .1$ ．The letter name／vi／serves as the intermediate form or key－ word，much like／＇daltu／＇door＇serves as the intermediary between a letter shape and the phoneme／d／．The difference is that／＇daltu／is a meaningful word that relates to the shape of the letter，whereas／vi／isn＇t a meaningful word．To make modern keywords meaningful，«V＞could be associated with ／vaz／vase rather than／vi／and the letter could be drawn as a vase with some flowers inside．Alphabet books sometimes use this approach（ $\$ 7.2 .2$ ）．Pictorial mnemonics of this sort are sometimes used in phonics instruction as well． Several studies have examined the factors that contribute to the success of pic－ torial mnemonics．For example，it is more helpful when teaching children that $\langle V\rangle$ goes with vase to present a picture of a vase that includes the $V$ shape than a picture of a vase that doesn＇t include this shape（Ehri，Deffner，\＆Wilce，1984）． A potential problem with incorporating letter shapes into pictures，however， is that children may not transfer the sound they have learned to the unembel－ lished shape．They may not know which parts of the picture of the vase are meant to be the shape of the letter and which details，such as the flowers，were added to make the picture more realistic．Heavy lines may be used for the letter shape and light lines for the details in order to show this，or the details may be gradually eliminated from the picture over the course of training（Agramonte \＆ Belfiore，2002；de Graaff，Verhoeven，Bosman，\＆Hasselman，2007）．Another problem with this approach is that appropriate objects may be difficult to find． For example，it isn＇t easy to find an object that is familiar to children that has a shape like 〈 H$\rangle$ and a name that begins with／h／．

Children often take advantage of the phonetic iconicity of letter names with－ out being explicitly taught to do so．For example，parents and teachers don＇t usually tell children that the names of letters often begin with their sounds． Whether explicit statements of this sort would benefit children hasn＇t，to our knowledge，been studied．

## 9．4 Should Children Learn Letter Names？

We have seen that children who are familiar with the names of letters often use the names when they learn the letters＇sounds．These children first learn one arbitrary association－that between the letter＇s shape and its name．They then use that association to motivate another－that between the letter＇s name and the sound for which it stands．In some societies，however，children aren＇t very familiar with letter names because these aren＇t stressed much in homes or in schools．During the first year of formal schooling in England，for example， children are taught labels for consonants that consist of their most common
sounds，followed in some cases by $/ \partial /$ ．Children learn through drill and rep－ etition that $\langle\mathrm{B}\rangle$ is $/ \mathrm{b} \partial /,\langle\mathrm{S}\rangle$ is $/ \mathrm{s} /$ ，and so on．These labels are referred to as letter sounds，although that is a bit of a misnomer because $\langle\mathrm{B}\rangle$ corresponds to／b／，not／bə／．For vowels，children are taught what are often called the short sounds：／æ／for $\langle A\rangle, / \varepsilon /$ for $\langle E\rangle$ ，and so on．These are the sounds to which the letters normally correspond in simple words such as pat and nest． Children use the taught letter sounds to decode and spell simple words．Only later，toward the end of the next year of schooling in a number of schools in England，are children formally taught the conventional letter names．Even then，however，letters aren＇t usually referred to by their names．For example， a child who asks how to spell bus would be told that it is／bə／followed by／$\Lambda$／ and／s／．Questionnaire studies confirm that teachers and parents in England place more emphasis on letter sounds and less emphasis on letter names than their counterparts in the US（Ellefson et al．，2009）．Children＇s performance on tests of letter name and sound knowledge shows corresponding differences （Caravolas，Kessler，Hulme，\＆Snowling，2005；Ellefson et al．，2009）．

Several arguments may be given for the policy of not stressing conventional letter names with children，or even for not teaching letter names at all．Some of the arguments involve utility．Letter names directly benefit spelling and reading mostly for initialisms like CNN（Cable News Network）；labels like／s／ and／bə／may be more generally useful．Another argument is that it might be easier for children to remove the $/ \partial /$ from a letter sound／bə／than the／i／ from a letter name／bi／because／／can＇t form phonotactically legal words at the end of monosyllables．For a letter sound such as $/ \mathrm{m} /$ ，no phoneme needs to be removed．Still another argument against conventional letter names is that some letter names in some languages aren＇t closely related to the letters＇ sounds．Teaching an English－speaking child the name of＜W＞could cause errors，as we have seen．However，this argument doesn＇t apply in many lan－ guages，including Turkish and Korean．

Advocates of conventional letter names counter that teaching names late or not at all can be problematic when a letter symbolizes more than one sound． For example，«C＞often corresponds to／k／but sometimes to／s／in English． Teaching the letter as $/ \mathrm{k}$／may obscure the fact that it corresponds to $/ \mathrm{s} /$ when followed by $\langle\mathrm{E}\rangle,\langle\mathrm{I}\rangle$ ，or $\langle\mathrm{Y}\rangle$ ，as in cent，cinnamon，and $c y c l e$ ．Also，labeling letters by their sounds can be ambiguous in some languages，because different letters may have the same sounds．In England，where the label／kz／is used for $\langle\mathrm{K}\rangle$ as well as $\langle\mathrm{C}\rangle$ ，a child who is told that a word is spelled with $/ \mathrm{k} \partial /$ won’t know whether to write 〈K〉 or 〈C〉．Parents and teachers in England sometimes deal with this problem by calling «K＞＇kicking／kə／＇and «C＞＇curly／kz／＇．Those labels，however，lack economy．Similar problems arise for several Hebrew let－ ters．For example，／tə／could refer to either ת／taf／or ט／tet／（Table 9．2）．

Letter names provide a way to refer to letters in a general sense．Using letter names，an adult can explain to a child that the letter／$\overline{\mathrm{d} 3} \mathrm{i}$／sometimes symbolizes one sound，as in get，and sometimes symbolizes another sound， as in gem．It is useful to have a word that refers to the letter as a class rather
than only a word that refers to the letter＇s sound，just as it is useful to have a word that refers to cats as a class in addition to a word that refers to the sound cats make．Indeed，despite the emphasis on letter sounds in England，teach－ ers there sometimes use conventional letter names when teaching children to form letter shapes（Ellefson et al．，2009）．Another argument for conven－ tional letter names is that labels such as／bə／and／s／aren＇t phonotactically legal words of English．They may be somewhat difficult to remember and pro－ nounce for this reason．

One can teach children to label letters with isolated phonemes and sequences of a consonant followed by $/ \partial /$ ，as training studies（Levin et al．， 2006）and the experience of educational initiatives such as that of England （Ellefson et al．，2009）show．But there is also the natural experiment showing that alphabetic writing systems，even those that don＇t have letters that corre－ spond to more than one phoneme or phonemes that may be spelled in more than one way，have developed wordlike letter names．Children and adults often prefer them，suggesting that the attractions of wordlike letter names run deep．

Whether the labels that children learn first for 〈 H$\rangle$ ，〈Q＞，and 〈S〉 are／hə／， $/ \mathrm{kw} \partial /$ ，and／s／or／et $\overline{\mathrm{J}} /$ ，／kju／，and／عs／，children use the labels they know to learn other things about the letter．Thus，when children in England are intro－ duced to the conventional names of letters，they learn 〈P’s name more easily than 〈Q〉＇s name because the label they already know is more helpful in the former case（／pi／is closely related to／pə／）than in the latter case（／kwə／isn＇t so closely related to $/ \mathrm{kju} /$ ）（Ellefson et al．，2009）．English children sometimes even say that／kwi／is the name of «Q＞or that／si／is the name of «S＞based on the labels that they know and their knowledge that many letter names consist of a consonant phoneme followed by／i／．English children＇s errors in learning letters＇names，like US children＇s errors in learning letter sounds，reflect their use of old knowledge to guide the acquisition of new knowledge．

## 9．5 Names of Auxiliary Marks

Written languages often include auxiliary marks that don＇t stand directly for individual segmental phonemes．In many cases，these are diacritic marks that appear above or below letters．In other cases，as with the symbol $\mathbf{b}$ ，which is used in Russian to show that the preceding consonant is palatalized，auxil－ iary marks are similar in appearance and placement to phonographic letters． Learning about a writing system involves learning about the auxiliary marks as well as about the basic symbols．In this section，we consider the properties of the names of auxiliary marks．Unfortunately，no systematic studies have yet examined children＇s learning of these names．

The name of a letter typically signals its function，containing as it does a sound for which the letter stands．The name of an auxiliary mark sometimes also reflects its function．In Slovak，for example，the acute diacritic＜＇＞may appear above vowels，$\langle\mathrm{L}>$ ，and $\langle\mathrm{R}\rangle$ to indicate the lengthening of the sound．

Its name, dížeň 'lengthener', expresses that function. The háček diacritic 〈̌> in Slovak is called mäkčeň 'softener', an attempt to describe how the diacritic changes the pronunciation of the consonant on which it appears, a sort of palatalization. It is analogous to the just-mentioned $\mathbf{ь}$, a mark of palatalization that is called мягкий знак 'soft sign'. It's hard to describe a sound, however, just as it's hard to describe the taste of wine. Some function-based labels are rather vague, as with the German term umlaut for a pair of dots above a letter. The term literally means that the sound has changed, but the nature of the change isn't stated. Some diacritics don't have a consistent function. In French, for example, the acute diacritic has a different function when it appears on «a> than when it appears on «e>. In such cases, no function-based name could fit all of the uses of a diacritic.

Given the difficulties with function-based names, the names of auxiliary marks are in many languages descriptions of their shapes. Indeed, shape-based names are much more common for auxiliary marks than for letters. Consider the names for the diacritic «» > in various languages: háček ‘little hook’ in Czech, strešica 'little roof' in Slovenian, kvačica 'small hook' in Croatian, and hattu 'hat' in Finnish. Other shape-based names include the Slovak dve bodky 'two points' and the Finnish pisteet 'dots' for the diacritic that consists of two dots: <">. Shape-based names may be used even when a diacritic has a consistent function across a series of letters. In Czech, for example, the acute diacritic may appear on vowels to indicate lengthening. However its name, čárka 'little line', reflects its shape. Welsh has a diacritic that may be used on any vowel to indicate lengthening, the circumflex <^〉. It, too, has a shape-based name, to bach 'little roof'. The names of some diacritics began as description of their shapes but have become opaque. Examples include the French circumflexe and the Portuguese circunflexo for the circumflex diacritic. This name originally meant 'bent about', but many users of these languages wouldn't know that.

More transparent names may be adopted for use with children, and these names often continue to be used informally by adults as well. For example, children and their teachers call the circumflex chapeau 'hat' or petit chapeau 'little hat' in French and chapeuzinho 'little hat' in Portuguese. Similarly, the tilde diacritic $\underset{\sim}{\sim}\rangle$ is called cobrinho 'little snake' rather than til by Portuguese-speaking children, who call the cedilla diacritic < ${ }_{s}$, rabinho 'little tail' or even rabinho de porco 'little tail of a pig' rather than cedilha. In Japanese, the diacritic <"> that is added to syllabograms to show that the consonant is voiced is formally called dakuten 'voicing dots'. However, children usually call it ten-ten, 'dot dot', preferring to emphasize its shape and ignore its function. These names probably help children to learn the shapes, although we know of no research on the topic.

The names of auxiliary symbols are like the names of letters in that they follow the phonotactic patterns of the language. However, they are less similar to one another than the names of letters are. The names of auxiliary marks are often words that are used in other contexts, and they are longer and more phonologically redundant than the names of letters. These things make the
names of auxiliary marks relatively uneconomical to produce. This may be acceptable, however, because people don't talk about auxiliary symbols as often as about letters. For example, it isn't always necessary to label a diacritic when a letter with a diacritic has its own name and its own place in the alphabet. If a Spanish-speaking child writes «n» instead of «ñ, an adult will typically say that the child should have used /'ene/ rather than /'ene/. The adult probably won't say that the child omitted the tilde. The fact that children hear different sorts of names for auxiliary symbols, together with the fact that auxiliary symbols don't have their own place in the alphabet, may help children to place auxiliary symbols into a separate category. Children may infer from the names that shape is important for auxiliary symbols, whereas sounds are important for letters.

Although many auxiliary marks are diacritics, not all diacritics are auxiliary marks. In an abugida such as Kannaḍa, for example, diacritics can represent vowels. When diacritic marks represent vowels in abugidas, their names follow the same principles that were described earlier in the chapter.

### 9.6 Theories

The theories that we discussed in chapter 4 acknowledge the importance of letter knowledge as an important foundation stone for spelling. According to phase theory $(\mathbb{\$} 4.4)$, children in the partial alphabetic phase of spelling development are often familiar with the names of letters, and the spellings that they produce are influenced by this knowledge. However, phase theory has devoted little attention to the question of how children learn letter names. The same is true for most other theories.

IMP $(\mathbb{\$} 4.6)$, which emphasizes that children learn general patterns as well as specific items, applies to the learning of letter names as to the learning of other aspects of writing. According to IMP, some of the patterns that children learn when learning about a writing system are purely formal. Formal patterns may be divided into two categories: those that pertain to the visual appearance of writing and those that pertain to the sound shapes of language. We discussed patterns of the former sort in chapters 5 and 8 , which dealt with the general appearance of texts and the shapes of specific characters, respectively. In this chapter, we have considered the formal properties of letter names as words of a language. Letter names follow certain phonotactic patterns by virtue of being words, and they follow some additional patterns as well. For example, the English letter name /vi/ has the phonological characteristics of English words in general and the phonological characteristics of English letter names in particular. The research we have reviewed suggests that children use their knowledge about the phonotactic patterns of their language when learning letter names. Children also learn about the additional phonotactic patterns that characterize letter names. Children supplement their knowledge of the phonological forms of specific letter names with their knowledge of the general patterns that apply to letter names as a group. The skills that children use in
order to learn letter names as words are thus similar to the skills that they use to learn other words of their language.

Learning about writing, according to IMP, involves not only the learning of formal patterns but also the learning of patterns that link units of writing and their functions. The sound shapes of most words don't provide a clue to the concept for which the word stands. For a word like cat, that is, learning the phonological form doesn't provide a leg up in learning the meaning. The sound shapes of most letter names do provide a leg up: The name of the letter is generally iconic, in that it includes the sound. From an early age, children who are familiar with letter names take advantage of this phonetic iconicity to help learn the links between letter names and the sounds for which the letters stand.

### 9.7 Conclusions

Most letter names have an intrinsic connection to the sound to which they refer. They contain that sound, often at the beginning. From an early age, children who are familiar with letter names benefit from these connections. They do so even though the connections aren't usually explicitly pointed out to them and even though such connections don't exist with the names of most other objects. That phonetic iconicity is virtually the rule in letter name systems shows the value of motivated associations over arbitrary ones. Spoken languages can't usually incorporate iconicity as a way of motivating associations between the phonological forms of words and the things for which they stand. Letter names are one area where they can and do.

A child who can say that $\langle\mathrm{V}\rangle$ corresponds to the sound /v/ when he sees this letter in isolation has a start in learning to spell. However, linking isolated sounds to letters is quite some distance from spelling entire words. In the next chapter, we consider how children begin to spell words.

Early Spelling in Phonographic Writing Systems

ANA, A BRAZILIAN 5 -year-old who spells luz 'light' as «EARS», and Shaquetta, a US child who spells will as «OHET», are in some sense writing. They are arranging letters of the Latin alphabet from left to right along a horizontal line, and they are using letters and letter sequences that are common in their writing system. Although Ana and Shaquetta know some things about writing, they aren't choosing letters to symbolize sounds. In an important sense, they aren't really spelling. A year later, these children have begun to produce spellings that reflect phonology. For example, Ana now produces spellings such as <qio> for querido /ke'ridu/ 'dear'. This spelling represents some but not all of the words' phonemes. In this chapter, we ask how learners of phonographic writing systems begin to symbolize the sounds of language and why they invent the spellings that they do. We focus on learners of alphabets, which represent speech at the level of phonemes, because most of the research involves learners of these systems.

We begin the chapter ( $(10.1)$ by reviewing research relevant to the constructivist $(\$ 4 \cdot 3)$ idea that the first links that children make between speech and print are at the level of the syllable. According to this theory, children in the syllabic stage of spelling development take letters to represent syllables. Thus, Ana wrote $\langle\mathrm{q}\rangle$ to represent the first syllable of querido, $/ \mathrm{ke} /$; <i> to represent the second syllable, /ri/, and «o» to represent the third syllable, /du/.

Other theories see spellings such as <qio» for querido /ke'ridu/ as attempts to represent phonemes rather than syllables. Some advocates of one such theory, phase theory $(\mathbb{\$} 4.4)$, have suggested that children's knowledge of letter names is an important determinant of the spellings that they produce during the partial alphabetic phase. Thus, Ana may omit the /e/ of /ke'ridu/ because <q>, named /ke/ in Portuguese, seems to her a valid way to represent both /k/ and $/ \mathrm{e} /$. We address these issues in a section on the role of letter names in early spelling ( $\$ 10.2$ ).

In later sections, we discuss how children's difficulties in analyzing words into smaller units of sound can lead them to spell using chunks that are larger than single phonemes ( $(\mathbb{1 0 . 4})$. Other spelling errors arise because, even when children succeed in analyzing speech at a fine-grained level, they may not classify phones into phonemes in the way that their writing system does. We also review research showing that children's early spellings aren't guided by phonology alone ( $(10.5)$. As we discuss, these findings are consistent with IMP's view that children use different types of patterns from early on, nonphonological as well as phonological ( $\$ 4.6$ ). Use of phonological patterns requires a degree of knowledge about language and its units that can be difficult for young children. In the final section of the chapter, we consider the implications of the research on early spelling for teaching ( $(\mathbb{1 0 . 6}$ ).

### 10.1 Do Beginners Spell Using One Symbol for Each Syllable?

The constructivist theory of literacy development, as discussed in $\$ 4 \cdot 3$, maintains that the first links that children make between speech and print are at the level of the syllable. Children invent the idea that each letter stands for a syllable even if they aren't exposed to a writing system that works this way. During the syllabic stage of development, children tend to spell words using one mark for each syllable. But doing so for one- or two-syllable words would violate another idea that young children are thought to hold: A word must contain multiple symbols, for most children at least three. Constructivist researchers suggest that children may abandon this minimum quantity hypothesis during the syllabic stage. Alternatively, children sometimes spell short words using more symbols than syllables but assign no sound value to the extra letters.

Some spellings produced by learners of alphabetic writing systems, especially Romance languages such as Italian, Portuguese, and Spanish, are at first glance consistent with the idea that children go through a syllabic stage in the development of spelling skill. For example, an Italian child spelled primavera 'spring' as 〈IAEA> (Pontecorvo, 1996) and a Portuguese-speaking child spelled urubu 'vulture' as <UUU> (Nunes Carraher \& Rego, 1984). There are also reports of learners of Spanish using a mark other than a conventional letter for each syllable in a spoken word (Ferreiro \& Teberosky, 1982). Although constructivist researchers report that a number of young children are in this syllabic stage, the researchers haven't always provided detailed criteria about their classification criteria. According to one study that provided more than the usual amount of information, an important consideration was how children read their spellings after having produced them (Vernon \& Ferreiro, 1999). Children were classified as being in the syllabic stage if they pronounced a syllable while pointing to an individual letter or a group of letters. This meant that children could be considered syllabic even if the number of letters in their
spellings never matched the number of syllables in the words being spelled. Children were assigned to the prior stage, the presyllabic stage, if they read their spellings without breaking them up. This is an unusual criterion, given that skilled readers normally do this. The number of symbols in a child's spellings thus wasn't the primary consideration for determining whether the child was in the syllabic stage.

Researchers who have carefully examined children's spellings have found little evidence for a stage of development during which the number of letters in a child's spellings matches the number of syllables in the words' spoken forms. This is true both in Portuguese, a Romance language, and in English (Cardoso-Martins, Corrêa, Lemos, \& Napoleão, 2006; Pollo, Kessler, \& Treiman, 2005; Pollo, Kessler, \& Treiman, 2009; Treiman, Pollo, Cardoso-Martins, \& Kessler, 2013). For example, Cardoso-Martins et al. (2006) tested Brazilian children at two points in time. At each time, the children spelled words that varied in length between one and four syllables. On the first test, just 5 of 124 children produced spellings that had the same number of letters as syllables on more than half of their attempts; only 8 children did so on the second test. Examining the less advanced children's performance on three- and four-syllable words, where any tendency to produce syllabic spellings shouldn't be counteracted by the tendency to avoid very short spellings that is predicted by the minimum quantity hypothesis, the researchers found that the children's spellings of the four-syllable words weren't reliably longer than their spellings of the three-syllable words.

Some of the spellings mentioned by constructivist researchers, including <AO〉 for the Spanish sapo 'frog' (Ferreiro \& Teberosky, 1982), point to another factor that may influence early spelling: children's knowledge of letter names. When writing /sapo/, it appears, this child spelled both of the vowel phonemes with the letters that have the corresponding names. We turn to the role of letter names in early spelling in the next section.

### 10.2 Letter Names and Early Spelling

Children use what they know to learn new things, in spelling as in other areas. As we discussed in $\S 9.2$, children in literate societies may know the names of some letters before they start to spell words. The research that we review in this section shows that such children use their knowledge of letter names to spell, sometimes writing a sound or sound sequence that matches a letter name or that is similar to a letter name with the corresponding letter. Whereas some theorists have claimed that children use letter names whenever it is possible to do so (Gentry, 1992), we will see that children are more likely to use a letter name to spell a sound sequence that is a cohesive chunk, one that is hard to analyze into phonemes, than a sound sequence that is less cohesive. We begin our discussion of the effects of letter names on children's early spelling with the case in which children use the whole name of a letter in spelling a word.

We then proceed to cases in which children match part of a letter name, or make an inexact match.

### 10.2.1 Spellings With Whole Letter Names

The most basic letter-name strategy in spelling is to use a letter to symbolize all of the sounds in its name. All languages include at least some words that contain phonemes and phoneme sequences that are the names of letters. For example, the name of $\langle\mathrm{A}\rangle$ is heard in the English words make and able and the name of $\langle\mathrm{B}\rangle$ is heard in stubby and beak. Children who try to spell such words may symbolize the phoneme or phoneme sequence with the corresponding letter, if they are familiar with the letter's name and shape. Consider Paul, a US 5-year-old. Not having succeeded in getting his mother's attention in standard ways, he used rubber stamps that had uppercase letters on them to form «RUDF» "Are you deaf?" (Bissex, 1980). His renditions of are /aı/ and you /ju/ used whole letter names, and his spelling of deaf /def/ combined the whole-letter-name strategy ( $/ \mathrm{F}\rangle$ for $/ \mathrm{\varepsilon f} /$ ) with another approach for $/ \mathrm{d} /$. Such anecdotal evidence for the use of letter names is supported by research findings described later in this section.

To take a closer look at whole-letter-name spellings, we begin our survey of the research findings with studies that have looked at vowels. The names of vowel letters are single vowel phonemes in most languages. When children who are familiar with letter names hear one of these phonemes in a spoken word, they sometimes write it with the corresponding letter. Thus, the most frequent spellings of US youngsters for /e/, /i/, /aI/, /o/, and /ju/ in one study were the letters that these sounds name: 〈A〉, E$\rangle,\langle\mathrm{I}\rangle,\langle\mathrm{O}\rangle$, and $\langle\mathrm{U}\rangle$, respectively (Read, 1975). These are the conventional spellings of the vowels in such words as he and go, and exposure to such spellings partly explains the high rate at which children use these letters. However, US 6-year-olds use these letter-name spellings more often than one would expect given the frequency of the correspondences in conventional print (Treiman, 1993). That is, spelling like <seps> for sheeps and <plo> for pillow are motivated in part by children's knowledge of letter names.

Further evidence for the importance of whole-vowel-letter names in early spelling comes from examining the phonemes that children fail to spell. US children are more likely to omit vowel phonemes that aren't the names of letters, such as $/ \mathrm{J} /$ and $/ \mathrm{J} /$, than vowel phonemes that are the names of letters, such as /i/ (Read, 1975; Treiman, 1993). Portuguese-speaking youngsters more often omit phonemes such as /o/ that aren't the names of letters in their language (Table 9.1) than phonemes such as /a/, the Portuguese name of <A> (Pollo et al., 2005). Additional evidence comes from a study in which spellings such as <el> for eel or <ma> for may were taught to US 4-year-olds over a series of trials. The children required fewer trials to learn these letter-name based spellings than to learn arbitrary spellings, consistent with the idea that the vowel letter names offered them some benefits (Bowman \& Treiman, 2008).

Dual－route theorists（ $\$ 4.2$ ）claim that shallow writing systems（in their usage， writing systems that have simple mappings from phonemes to phonograms） are easier to learn than deep ones（in their usage，those that include complica－ tions）．For young children who are familiar with letter names，however，the proportion of vowel phonemes that are letter names may be more important than orthographic depth as defined by dual－route researchers．While the pro－ portion of vowel phonemes that are letter names is probably related to ortho－ graphic depth，the relationship is far from perfect．In terms of the proportion of vowel phonemes that are letter names，Spanish is an easy language for learners．Spanish has just five vowels－／a／，／e／，／i／，／o／，and／u／—and these are the names of 〈A〉，〈E〉，〈I〉，〈O〉，and 〈U〉，respectively．Thus，any vowel in any word that a Spanish－speaking child tries to spell is the name of a letter．This is probably a major reason why young spellers of Spanish are less likely to omit vowels than consonants（Manrique \＆Signorini，1994，1998）．In many other languages，some vowel phonemes aren＇t the names of letters．Portuguese has some such vowels，including／o／and／e／，and English has many，including $/ \varepsilon /$ and $/ \cup /$ ．As a result，learners of Portuguese encounter more vowel letter names per word（an average of 1．9）than learners of English（an average of 0．4；Pollo et al．，2005）．In terms of the frequency of vowel letter names，then， English is more difficult for children than Portuguese，which is in turn more difficult than Spanish．

Languages differ not only in the proportion of their vowel phonemes that are letter names but also in whether the resulting letter－name spellings are correct．Spanish is one language in which the spellings that vowel letter names suggest are virtually always correct．The vowels in the Spanish word sapo＇frog＇ are $/ \mathrm{a} /$ and $/ \mathrm{o} /$ ，which are the names of $\langle\mathrm{A}\rangle$ and $\langle\mathrm{O}\rangle$ ，and the correct spellings of these vowels in sapo and in other words are «a〉 and «o»．In certain other lan－ guages，vowel letter names don＇t yield correct spellings as often as they do in Spanish．English is one such language．For example，the vowel of train／tien／ is spelled with «ai» rather than with single «a＞and drape／diep／has a final «e＞ in addition to the＜a that is suggested by the letter name．Children who rely on letter names to spell the vowels of train and drape will omit the＜i＞of «train＞ and the final «e〉 of＜drape»．Indeed，US children sometimes misspell words with final «e» even after several years of formal literacy instruction（Beers， Beers，\＆Grant，1977；Varnhagen，McCallum，\＆Burstow，1997）．These chil－ dren understand the function of＜a＞in＜train＞and «drape＞－this letter symbol－ izes the sound it names－but they don＇t understand the functions of strain＇s ＜i» and＜drape»＇s «e»．French is similar to English in that it spells some vowels with a sequence of letters，only one of which motivated by a letter name．In ／bufbi／boucherie＇butcher＇，for example，the／i／in the final syllable（which is the name of the letter 〈I＞）motivates the＜i＞but not the «e＞of the conventional spelling．Correspondingly，there are reports of children spelling this word with ＜i＞rather than «ie＞at the end（Jaffré，1992）．

In the English and French examples we have been discussing，includ－ ing train，drape，and boucherie，a vowel letter name motivates one letter of
a conventional spelling but not another．In other cases，vowel letter names suggest letters that don＇t appear in a word＇s conventional spelling at all．For example，English speakers who rely on letter names would end their spelling of pony／＇poni／with «e＞rather than＜y＞．This is indeed a common error among US youngsters（Pollo et al．，2005）．Francophones who rely on letter names would use «o» in／tablo／tableau＇table＇，as some French children do（Jaffré， 1992）．Another example comes from Portuguese，where sapo／＇sapu／＇frog＇is pronounced with a final $/ \mathrm{u} /$ ．But $/ \mathrm{u} /$ is the name of $\langle\mathrm{U}\rangle$ ，not $\langle\mathrm{O}\rangle$ ，and so a child who uses the names of vowel letters would spell sapo with a final＜u＞．The large majority of Brazilian 5－year－olds＇errors on such words are of this type（Pollo et al．，2005），children using＜u＞even though it is less common at the ends of Portuguese words than $\langle 0\rangle$ is．In a number of the cases we have been discuss－ ing，the spelling of a phoneme that is suggested by the letter name is wrong for the word in question but right for other words．For example，«e» is wrong for／i／in pony but right for he／hi／and demon／＇dimən／．Children＇s experience with «e» as a spelling of／i／in words of the latter type may promote such errors as «pone» for pony．

According to one estimate，around a quarter of the letter name vowels in both English and Brazilian Portuguese are unreliable guides to spelling in that the spelling suggested by the letter name isn＇t the conventional spelling of the vowel in that word and isn＇t even part of the conventional spelling（Pollo et al．， 2005）．That is，English and Portuguese contain a fair number of words such as pony and sapo．As we have discussed，such words are much less common in Spanish．The reliability of letter－name spellings is a dimension on which writ－ ing systems differ，a dimension that may be important for beginning spellers beyond orthographic depth as typically defined．

We turn now to whole－letter－name spellings of consonants．The names of consonant letters always contain at least two phonemes，and in some lan－ guages more than two．Children who use a whole consonant letter name iden－ tify a sequence of phonemes such as the／عf／in deaf and symbolize the entire sequence with a single letter．Treating a sequence of phonemes as a unit is attractive because it allows children to circumvent a problem that they would otherwise face：analyzing a phonological chunk into smaller units．Thus， children sometimes use whole consonant letter names to guide their spell－ ing．Anecdotal reports，such as Paul＇s «R» for are and «DF» for deaf（Bissex， 1980），are confirmed by the results of naturalistic and experimental studies． For example，the US 5 －and 6 －year－olds in one experiment frequently spelled nonwords such as／var／as «VR»，using 〈R» to symbolize its name（Treiman， 1994）．Four－and five－year－olds who knew the letter name more often spelled ／vas／as just 〈R〉．Indeed，some of these younger children produced spellings such as $\langle\mathrm{R}\rangle$ for／vaı／and＜T＞for／tib／at the same time that they wrote other syllables in a nonphonological manner．The ready－made link between／as／and ＜R＞helped these children to spell at least some items phonologically．

It isn＇t just US children who use whole consonant letter names as guides to spelling．In one study，Portuguese 5 －and 6－year－olds were more likely to use
a phonetically accurate consonant letter when the letter＇s full name occurred in a word than when it didn＇t（Alves Martins \＆Silva，2001）．For example， the children more often used＜z＞，named／ze／，when spelling zebra／＇zebra／ ＇zebra＇than when spelling zinco／＇zîku／＇zinc＇．Similarly， 5 －year－old Portuguese speakers from Brazil were more likely to spell the initial＜t＞，named／te／， in／tele＇fõni／＇telephone＇than in／tahta＇ruga／＇turtle＇（Cardoso－Martins \＆ Batista，2005）．

In the English and Portuguese cases just described，the consonant letter names that children use in spelling contain two phonemes．In some lan－ guages，including Portuguese，Hebrew，and Arabic，some letter names con－ tain more than two phonemes．Children take advantage of these longer letter names as well．Thus，the 5 －year－old Arabic speakers in one study were better at reporting that／si：na：？／سيناء＇Sinai＇began with the letter named／si：n／than that／safi：na／سفينة＇ship’ began with this letter（Levin，Saiegh－Haddad，Hende， \＆Ziv，2008）．Young spellers of Hebrew were more likely to use a letter at the beginning of a word when the letter＇s full name was heard in the spoken word than when just the first phoneme of the letter＇s name was heard．For example， children produced the letter $\beth$ ，whose name is／bet／and which is the only let－ ter that spells／b／，more often for the word／＇beten／＇belly＇than for the word ／＇boker／＇morning＇（Levin，2007；Levin，Patel，Margalit，\＆Barad，2002）．These children sometimes followed the $\boldsymbol{z}$ that they wrote at the beginning of／＇beten／ ＇belly＇with the letter J ，which spells $/ \mathrm{n} /$ ，suggesting that they considered $\boldsymbol{\imath}$ suf－ ficient to symbolize all of the sounds in its name．Some of the Israeli children in the study produced spellings of words like／＇beten／that were based on letter names at the same time that they wrote words like／＇boker／with letters that were unrelated to the word＇s sounds．Again，use of whole letter names helped children to embark on phonological spelling．

Even after use of phonology has taken root for a wide range of words，chil－ dren＇s choices of phonograms continue to be influenced by their knowledge of consonant letter names．Consider／s／，which is sometimes spelled in English with «C»，as in cent，and sometimes $\langle S\rangle$ ，as in sent．When a word begins with the phoneme sequence／si／，which is the name of «C〉，US children are especially likely to choose 〈C〉 to spell it（Ellefson，Treiman，\＆Kessler，2009；Treiman， Tincoff，\＆Richmond－Welty，1996）．Similarly，Hebrew／k／may be spelled either Ј，named／kaf／，or p，named／kuf／（Table 9．2）．Children favor p for words like ／kuf＇ta／＇dumpling＇and／kuf＇sa／＇box＇，which begin with the phonemes／kuf／ （Levin，2007；Levin et al．，2002）．The letter p is correct for／kuf＇sa／קופסה＇box＇ but not for／kuf＇ta／כופתה ‘dumpling＇．As these examples show，children’s reli－ ance on consonant letter names can affect their performance on phonemes that have more than one possible spelling，leading to correct spellings in some cases but errors in others．

The research we have reviewed doesn＇t support the idea that all consonant letter－name sequences are equally susceptible to letter－name spellings（Gentry， 1982）．Instead，some sequences are more cohesive chunks than others，more likely to be spelled on the basis of whole letter names．These considerations
help to explain why whole－letter－name spellings involving «r» are more com－ mon and more persistent among US children than whole－letter－name spellings of other consonants（Treiman，1993，1994）．The sound／ $\mathrm{x} /$ ，an approximant，is very similar to a vowel，and the transition from a vowel to a following $/ \mathrm{x} / \mathrm{is}$ smooth and gradual．This similarity and the absence of an abrupt phonetic boundary between the two sounds make it difficult to break up such a sequence into two separate phonemes．Thus，US 6 －year－olds may say that／vaı／contains two rather than three sounds（Cassar，Treiman，Moats，Pollo，\＆Kessler，2005； Treiman \＆Cassar，1997）．Even adults may treat vowel－／I／sequences as units （Treiman，1984b；Treiman \＆Cassar，1997）．When analyzing a word like bar for purposes of spelling，children may treat it as $/ \mathrm{b} /$ and／as／rather than as $/ \mathrm{b} /$ ， $/ \mathrm{a} /$ ，and $/ \mathrm{d} /$ ．Consequently，children may write $\langle\mathrm{br}\rangle$ ．

US children produce some whole－letter－name spellings with consonants like＜L»，reflecting analysis of a word like／bel／into／b／and／عl／．However， whole－letter－name spellings are less common with «L〉 than 〈R〉（Treiman， 1993，1994）．This difference may reflect a perception that the sounds in the sequence $/ \varepsilon l /$ ，the letter name of $\langle L\rangle$ ，are more dissimilar to each other than are the sounds in the sequence $/ \mathrm{a} \lambda /$ ，the name of $\langle\mathrm{R}\rangle$ ，and are therefore a little easier for spellers to break into two separate sounds．Also，／a／appears at the beginning of $\langle\mathrm{R}\rangle$ and no other English letter name，whereas $/ \varepsilon /$ appears at the beginning of several letter names besides «L»．Children become accustomed to removing $/ \varepsilon /$ from letter names like $/ \varepsilon l /$ and $/ \varepsilon s /$ and $/ \mathrm{i} /$ from letter names like／bi／and／vi／，but／ax／is the only letter name that requires removal of ／a／．Whole－letter－name spellings involving the other consonants whose names begin with $/ \varepsilon /(\langle\mathrm{F}\rangle,\langle\mathrm{M}\rangle,\langle\mathrm{N}\rangle,\langle\mathrm{S}\rangle$ ，and $\langle\mathrm{X}\rangle)$ are less common than those involv－ ing $\langle\mathrm{R}\rangle$ or $\langle\mathrm{L}>$（Treiman，1993，1994）．This difference probably reflects the fact that these letter names end in sounds that are less vowel－like than the approxi－ mants $/ \mathrm{x} /$ and $/ \mathrm{l} /$ and are therefore easier to discern as separate from the vowel that precedes them．

Children use letter names to some extent with consonants such as／t／and $/ \mathrm{v} /$ ，as shown by the fact that US youngsters found it somewhat easier to learn simplified spellings such as $\langle\mathrm{tm}$ » for／tim／，in which the name of the initial letter is heard in the spoken word，than spellings such as＜tm＞for／tem／，in which the name of the initial letter isn＇t heard（Treiman，Sotak，\＆Bowman， 2001）．However，whole－letter－name spellings are less common for consonants like／t／and／v／than they are for／ $\mathrm{I} /$ and／l／（Treiman，1993，1994）．The for－ mer consonants are plosives and fricatives，which are very different from vow－ els．This makes it relatively easy for children to discern the difference between the two sounds in letter names like／ti／and／vi／．

When children spell an entire consonant letter name with a single letter， that spelling is usually wrong．This is because，in most languages，the conven－ tional spelling of a sequence that includes a vowel phoneme，as consonant let－ ter names do，almost always includes a vowel letter．For example，English／aı／ is spelled＜ar» in car and＜er＞in sergeant．Its spelling virtually always includes a vowel．In some abjad－style scripts（ $\mathbb{\$ 2} 5$ ），letter－name spellings of some
consonants would produce correct spellings．For example，the Persian letter is named $/ \mathrm{je} /$ ，and it is the first letter of the word／jek／＇one＇．If a child began the word／jek／＇one＇with a $s$ ，thinking it represented the whole－letter－name sequence／je／，the result would be correct，because Persian has no overt rep－ resentation for the vowel／e／in the middle of a word．However，in all mod－ ern abjads，the vast majority of the consonant letter names contain additional sounds that have their own spellings．For example，in Persian，the consonant $/ \mathrm{d} /$ is spelled by the letter named $/ \mathrm{dbl} /$ ．In these cases，a spelling that is based on a whole consonant letter name is incorrect．

Although whole－letter－name spellings of consonants aren＇t usually fully correct，they are often partly correct in that they include one letter of the con－ ventional spelling．For example，«r＞for／as／includes one letter of the most common correct spelling of this sequence，«ar»，making «br» for bar a some－ what plausible error．According to one estimate，when a whole consonant letter name appears within a word，as in／＇dopi／，then the letter it names will appear in the conventional spelling（dopey）over $85 \%$ of the time in both English and Brazilian Portuguese（Pollo et al．，2005）．

In some cases，whole－letter－name spellings of consonants contain none of the correct letters．An example is the English seem，where the consonant let－ ter name／si／suggests a letter，〈c＞，that doesn＇t appear in the word．However， «c〉 does spell／s／in some other English words．With wife and wine，the letter name／waI／suggests a spelling，＜y＞，that is never correct for／w／．Children who know «y＞＇s name sometimes spell／w／this way（Ellefson et al．，2009； Treiman et al．，1996），and spellings like＜yf» for wife can be difficult for adults to decipher．Another example comes from Hebrew．Children sometimes con－ sider עטף／a＇taf／＇he wrapped＇to end with the letter／taf／ת because its spoken form ends with the phonemes／taf／，but in fact this and other words with final ／f／are never spelled with final／taf／（Levin et al．，2002；Levin，2007）．In such cases，children＇s use of consonant letter names leads to spellings that are far off the mark．

The research we have reviewed so far on the topic of consonant letter names shows that，when children encounter a sequence of sounds that is the name of a consonant letter，they sometimes spell that sequence with the corresponding letter．In many languages，though，this tendency will influ－ ence the spelling of only a small proportion of words．This is because some letter－name sequences aren＇t very cohesive phonologically and thus aren＇t very susceptible to whole－letter－name spellings．Also，consonant letter names contain at least two phonemes and may not be very common in words．The English words telephone and Jefferson contain one consonant letter name each，the names of 〈L〉 and 〈F»，respectively，but most English words con－ tain no such sequences．According to one estimate，less than one of every six English words contains a consonant letter name（Pollo et al．，2005）．The figure is similar for Brazilian Portuguese．Whole letter names are even less common in Hebrew words，given the relatively long letter names of that lan－ guage（Levin，2007）．

In any language，few words are composed only of letter names．English has cutie，with the names of 〈Q〉 and «D〉，and French has céder＇give up＇，with the names of «C» and «D＞，but the vast majority of words in English，French，and other languages aren＇t like these．This means that use of whole letter names， on its own，will allow children to spell only a few complete words．However， words that are composed only of letter names might play an important role in helping children to understand that writing symbolizes speech sounds． Anecdotal evidence for this point comes from one $3^{1 / 2}$－year－old of our acquain－ tance，Joe．For this child，«GI Joe» was the first spelling that seemed motivated rather than arbitrary．It includes two letters whose entire names are heard in the pronunciation，plus the familiar spelling of the child＇s name．

## 10．2．2 Partial and Inexact Matches to Letter Names

Children who were limited to exact matches would show a rather small influ－ ence of letter names，especially in some languages．However，the research to which we now turn shows that children aren＇t limited to exact matches．Just as a tailless cat is similar enough to other cats to merit the cat label，so one sound or sound sequence may be similar enough to another to merit the same spelling．Children are often willing to accept partial or inexact matches so that they can produce a spelling．They may be especially likely to satisfice in this way when the alternative is to write nothing or to omit a sound．In many cases， therefore，children spell a sound or sound sequence based on its similarity to another．They do this rather than inventing a new symbol，just as their ances－ tors borrowed symbols from other writing systems to represent similar but not identical sounds in their own languages．These things mean that the effects of letter－name knowledge on children＇s spelling can be rather broad．By examin－ ing which partial and inexact matches children accept，we can learn which sim－ ilarities among speech sounds are most salient to them for spelling purposes．

Consider Portuguese 〈Q＞，named／ke／．Young Portuguese speakers some－ times use $\langle\mathrm{Q}\rangle$ to spell／ke／，an exact match，but they sometimes also use $\langle\mathrm{Q}\rangle$ to spell／ge／，an inexact match（Pollo，Treiman，\＆Kessler，2008）．The sequence $/ \mathrm{ge} /$ matches $/ \mathrm{ke} /$ in the vowel and in all features of the consonant except voicing：the vocal cords vibrate for $/ \mathrm{g} /$ but not for $/ \mathrm{k} /$ ．The phoneme $/ \mathrm{g} /$ is never spelled with «Q＞in Portuguese，so a child who writes gueto／＇getu／ ＇ghetto＇with an initial «Q» isn’t using a conventional phoneme－to－phonogram mapping．Rather，the child seems to classify／ge／as similar enough to／ke／to merit the spelling of／ge／with the letter that is associated with $/ \mathrm{ke} /$ ，« Q ．In making this judgment，the child generalizes over voicing．Evidently，children consider consonants that differ in voicing and that are alike in other ways to be similar to one another．

The case of « Q » involves the name of a consonant letter．Children also make inexact matches that involve the names of vowel letters．For example，US chil－ dren sometimes spell $/ \varepsilon /$ with 〈A〉（Read，1975；Treiman，1993）．They do this，in part，because $/ \varepsilon /$ is similar to $/ e /$ ，the name of $\langle A\rangle$ ．As Table 10.1 shows，both are
table 10．1 Place of Articulation of American English Vowels

| HEIGHT | FRONT | CENTRAL | BACK |
| :--- | :--- | :--- | :--- |
| Close | i |  | u |
| Near close | I |  | U |
| Close－mid | e |  | o |
| Open－mid | $\varepsilon$ | $\partial$ | Ј，〕I |
| Open | $æ$ | au | ai，a |

pronounced in the front of the mouth，with the tongue raised about midway to the roof of the mouth．Vowels that are pronounced near each other tend to sound similar as well．Children evidently consider $/ \varepsilon /$ and $/ \mathrm{e} /$ to be similar enough to use a well－learned spelling that is appropriate for one vowel for the other vowel．

Although children consider $/ \varepsilon /$ as similar to $/ \mathrm{e} /$ ，skilled writers of English relate $/ \varepsilon /$ to／ $\mathrm{i} /$ ，calling the former＂short 〈 E$\rangle$＂and the latter＂long « E »．＂The use of the labels long and short for English vowels has a historical basis．Centuries ago，the long vowels were simply longer versions of the corresponding short vowels．At that time，English developed many cases where the same morpheme was pronounced with a long vowel in some words and a short vowel in other words（1）．But sound changes since those days have obscured the phonetic simi－ larity between long vowels and the corresponding short vowels．As Table 10.1 shows，pairs such as $/ \varepsilon /$ and $/ i /$ are still produced fairly near each other． However，pairs such as $/ \varepsilon /$ and $/ \mathrm{i}$／aren＇t more similar to each other than many other pairs of vowels．Morphologically related pairs such as serene and serenity still exist，but most such pairs comprise relatively sophisticated words from the Latinate portion of the vocabulary that children aren＇t familiar with before start－ ing school．This means that a young child who knows about the link between $/ \mathrm{i}$／and 〈E» on the basis of the letter name can＇t easily infer that $/ \varepsilon /$ should be spelled with 〈 E » as well．The same holds for the other vowel letter names．

（1） |  |  | Long |  | Short |
| :--- | :--- | :--- | :--- | :--- |
| A | ／e／ | sane | $/ æ /$ | sanity |
| E | ／i／ | serene | $/ \varepsilon /$ | serenity |
| I | ／ai／ | bite | ／I／ | bitten |
| O | ／o／ | verbose | ／a／ | verbosity |
| U | ／ju／ | unicycle | ／ə／ | undecagon |

So far，we have considered cases where a child selects a letter because its entire name matches or is similar to sounds in the word being spelled． Children also may select a letter when some but not all of the phonemes in its letter name occur in the word．Hebrew is a good language for studying such phenomena because of its relatively long letter names．In one experi－ ment，Hebrew－speaking 5 －year－olds found it easier to select a letter when the
consonants in its letter name were in the word being spelled，but not the vow－ els（Levin et al．，2002），or if the first two phonemes in the letter name were in the word（Levin，2007；Levin et al．，2002）．For example，children provided the correct initial letter，ג，which is named／＇gimel／，more often for גמל／ga＇mal／ ＇camel＇，which matches all the consonants of the letter name，than for גנב ／ga＇nav／＇thief＇，which shares only the first consonant with the letter name． Children also selected $ת$ ，named／taf／，more readily for words that began with $/ \mathrm{ta}$／than for words that began with／t／plus another vowel．

Yet another type of partial match occurs with the long letter names of Portuguese，where children sometimes match the stressed second syllable of a two－syllable letter name．This occurs with $\langle\mathrm{H}\rangle$ ，which has the name／a＇ga／． Although 〈 H 〉 never spells $/ \mathrm{g}$／in Portuguese，some 5 －year－olds use an initial〈 H 〉 for words like gado／＇gadu／＇cattle＇，which begins with the stressed syllable of 〈H’s name．Children rarely use 〈 H 〉 at the beginning of a word like gude ／＇gudi／＇marble＇，which doesn＇t contain the entire stressed syllable of the letter name（Pollo et al．，2008）．Matches of initial phonemes generally carry more weight than matches of final phonemes，but the stress on the final syllable of／a＇ga／overrides this．Although Portuguese－speaking children sometimes match the stressed／ga／of／a＇ga／，they don＇t appear to match the unstressed ／li／in the name of $\langle\mathrm{L}\rangle$ ，／＇ $\mathrm{Eli} /$. The children in one experiment were no better at spelling the initial／l／in a word like limão／li＇mãw／＇lime＇，which begins with the final syllable of the name of＜L＞，than in a word like laranja／la＇rãza／ ＇orange＇（Cardoso－Martins \＆Batista，2005）．The difference between this case and that of $\langle\mathrm{H}\rangle$ may be due to the lack of stress on the vowel following the $/ \mathrm{l} /$ ． Not only are unstressed vowels less salient in general than stressed ones，but unstressed vowels in final syllables can be shorter and more lax than unstressed vowels elsewhere in Brazilian Portuguese．It is possible that children may not readily equate the reduced vowel in／＇$\varepsilon$ li／with the unreduced vowel in a word like limão／li＇mãw／＇lime＇．

Portuguese－speaking children＇s use of $\langle\mathrm{H}\rangle$ to spell／ga／shows that they con－ sider the syllable／ga／to be similar to the disyllabic letter name／a＇ga／．These children＇s occasional use of $\langle\mathrm{H}\rangle$ to spell items beginning with／ka／（Pollo et al．， 2008）further shows that they consider／ ka ／similar enough to／a＇ga／to merit an $\langle\mathrm{H}\rangle$ spelling．Here，as with the Portuguese 〈Q＞mentioned earlier，children generalize over voicing．Children are more likely to spell $/ \mathrm{ka} /$ with $\langle\mathrm{H}\rangle$（where $/ \mathrm{k} /$ differs from $/ \mathrm{g} /$ in voicing）than to spell／ba／or／da／with 〈H＞（where／b／ and $/ \mathrm{d} /$ differ from $/ \mathrm{g} /$ in place of articulation）．The letter $\langle\mathrm{h}\rangle$ doesn＇t look very similar to 〈c＞，which would normally be used to spell $/ \mathrm{k} /$ in Portuguese，so the error appears to reflect phonological rather than visual factors．

Languages such as Hebrew and Portuguese，in which a number of letter names contain three or more phonemes，offer children the opportunity to make partial matches that involve less than a full letter name but more than a single phoneme．Other partial matches involve just one phoneme of a letter name．Indeed，this is the only possible partial match with the two－phoneme letter names that are typical of many languages．Consider the letter $\langle\mathrm{Y}\rangle$ ，named
／wai／in English．Young US children sometimes use $\langle\mathrm{Y}\rangle$ to spell the entire sequence／waI／，as mentioned earlier，but they sometimes use $\langle\mathrm{Y}\rangle$ to spell just the first phoneme of its name，／w／（Treiman，Weatherston，\＆Berch，1994）． Consider also the letter «U»，named／ju／in English．US children sometimes use 〈 $U$ 〉 to spell／ $\mathrm{u} /$ ，as in 〈pul〉 for pool（Treiman，1993）．The letter $\langle U\rangle$ is some－ times a conventional spelling of $/ \mathrm{u} /$ ，but young children use it more often than would be expected on that basis．The reason for this overuse must be that the name of $\langle\mathrm{U}\rangle$ contains $/ \mathrm{u} /$ ．A third example involves Spanish 〈 H$\rangle$ ，／＇at $\widehat{\mathrm{T}} \mathrm{e} /$ ． Young speakers of Spanish sometimes spell $/ \overline{\mathrm{t} ~} /$ with $\langle\mathrm{H}\rangle$ ，in part because they hear $/ \overline{\mathrm{tJ}} /$ in the middle of this letter＇s name（Temple，1980）．The fact that h ＞ is part of the standard＜ch＞spelling of $/ \overline{\mathrm{t}} /$ may also contribute to this error．In all of these cases，children appear to relate a phoneme that they wish to spell to a sequence of two or more phonemes that includes this phoneme and that they have learned as a letter name．The phoneme in question is the first ele－ ment of the letter name in the case of／wai／and the second in the case of／ju／ and／＇at5e／．We suggested earlier that matches of initial phonemes generally carry more weight than matches of later ones．However，children use matches in later positions when this can allow them to spell a phoneme for which they might otherwise find no letter－name model．

The partial matches that we have been discussing sometimes yield incor－ rect spellings．English speakers are always incorrect when they use＜y＞to spell／w／，and «u＞for／u／is sometimes incorrect．In Spanish，«h＞never spells $\overline{\mathrm{t} \mathrm{J} / \text { ．In many other cases，though，partial matches yield correct spellings．For }}$ example，English－speaking children who spell／b／as＜b＞because／b／is the first phoneme of 〈b＞＇s name have produced what is almost always the correct spelling．Children＇s ability to relate／b／to／bi／，and their tendency to spell the former with a letter they know to be appropriate for the latter，allow them to take advantage of the phonetic iconicity that characterizes most letter names in most languages．This，as discussed in chapter 9，is the fact that most letter names contain the sound for which the letter stands．

The similarity between a phoneme that a child wants to spell and a let－ ter name will be greater，in general，when the exact phoneme is heard in the letter name than when the match is inexact．As a result，children who use their knowledge of letter names in spelling will have difficulty with consonant phonemes that don＇t appear in a letter name．Many languages have such pho－ nemes．For example，／g／isn＇t heard in any English letter name．This helps to explain why US children have more difficulty spelling $/ \mathrm{g} /$ than spelling pho－ nemes such as $/ \mathrm{b} /$ and $/ \mathrm{v} /$ ，which do appear in the names of letters（Treiman， Weatherston，et al．，1994）．It also helps to explain why the child in one case study was more likely to ask an adult how to spell consonant sounds that didn＇t appear in letter names，such as $/ \mathrm{g} /$ and $/ \mathrm{S} /$ ，than consonant sounds that did （Bissex，198o）．

Although English contains some consonant phonemes that don＇t occur in the name of a letter，some languages contain few or no such consonants．In Hebrew，for example，all consonant phonemes appear in a letter name．We
suspect that the proportion of consonant phonemes that appear in the name of a letter is an important determinant of cross-language differences in young children's ability to spell consonants, just as the proportion of vowel phonemes that are the name of a letter is an important determinant of their ability to spell vowels. However, we don't know of any research on this point.

### 10.2.3 Conclusions About Letter-Name Spellings

Children who are familiar with the names and the shapes of letters, as many children are, sometimes use this knowledge when trying to spell words. The children find a phoneme or phoneme sequence in the word they are trying to spell that matches or is similar to a familiar letter name, and they spell it with the corresponding letter. This approach can yield spellings in which groups of phonemes are spelled with single letters, such as $\langle\mathrm{BR}>$ for bar, and spellings in which phonemes are represented with incorrect letters, such as 〈YAT> for wet. Phase theorists $(\mathbb{\$} 4.4)$ describe such spellings as partially alphabetic: The spellings represent some phonemes of a word in an appropriate way but don't represent others. The description may be accurate, but it doesn't go very far to explain why children produce the specific spellings that they do. The additional idea that children use letter names whenever possible, put forward by some researchers (Gentry, 1982), doesn't explain such things as why children are more likely to omit the <a> of bar than the $<\mathrm{e}>$ of mess.

IMP $(\mathbb{\$} .6)$ proposes that children use multiple patterns in spelling. Letter names are one influence, for children who are familiar with them, but they aren't the only influence. Children's knowledge of language is also influential, in this case their knowledge about the phonemes within those letter-name sequences that contain more than one phoneme. Children are less able to break up a letter name such as /ax/ than a letter name such as /es/, and this means that they are less likely to produce a whole-letter-name spelling for the former than for the latter. Thus, IMP can explain the differences among letters in their susceptibility to letter-name spellings that cause problems for other theories.

### 10.3 Other Labels

We have seen that children who know the conventional names of letters may use this knowledge when constructing their own spellings. In some societies, however, children aren't familiar with letter names when they start writing
 more likely to know «b> as /bə/ and «e» as $/ \varepsilon /$ than to know «b> as /bi/ and «e> as /i/. One study found that these children sometimes use a consonant letter such as «b» to symbolize the entire sequence that is its name, writing «gub> to spell /'gubə/ (Ellefson et al., 2009). The principle-spell a sequence of phonemes with a letter whose label matches the sequence, thereby avoiding
the need to analyze the sequence into phonemes-is the same one that underlies whole-letter-name spellings in US children. The result differs, however, because English children know different labels for letters. The labels that English children learn for vowel letters also influence their spelling. Given their familiarity with the link between $/ \varepsilon /$ and «e», for example, these children tend to be good at spelling the vowels of words like pet (Caravolas, Kessler, Hulme, \& Snowling, 2005; Treiman, Stothard, \& Snowling, 2013). English children make fewer errors like «kep» for keep and «tam» for tame than US children, supporting the idea put forward earlier that such errors in part reflect the use of letter names.

Children who learn labels for letters that reflect the letters' most common sounds make inexact matches as well as exact matches. Their inexact matches for letter sounds appear to reflect the same sorts of phonetic similarities as the inexact matches for letter names that were discussed earlier. For example, beginning spellers of Dutch, who learn the label $/ \varepsilon /$ for $« \mathrm{E}$ », sometimes extend this spelling to the vowel /l/ (van Rijnsoever, 1979). The vowel /I/ is fairly similar to $/ \varepsilon /$ in Dutch just as in English (Table 10.1).

In the cases discussed so far, children know a label for a single letter. Children sometimes learn labels for pairs of letters, too. For example, children in the Netherlands are taught «ee» as a unit, learning /e:/ as the label for it. Indeed, /e:/ is spelled as «ee> in many Dutch words, including those with a final consonant. In syllables without a final consonant, however, /e:/ is normally spelled «e». Dutch 6-year-olds typically write «ee» in both types of syllables, using the phonogram learned for /e:/ (van Rijnsoever, 1979).

Numbers have names, as letters do. Anecdotal evidence suggests that children occasionally use number names as guides to spelling. For example, one young French child wrote <a1> for lapin, presumably because the French word for 'one' sounds like the final part of lapin (Jaffré, 1992). Older children and adults may use such spellings in text messages, as in <18r» for later and «b4〉 for before.

### 10.4 Phonological Analysis and Classification

Children's invented spellings reflect the links that they observe between the phonological forms of words and their spellings. However, children's ability to learn about these links may be hindered by a difficulty in analyzing spoken words into smaller units. Phonemes, given their abstract nature, are especially difficult. As we have seen, children sometimes try to circumvent these difficulties by breaking up words into units that are larger than single phonemes. In this approach, children symbolize a sequence of phonemes with a letter that they have learned to associate with the sequence or with a letter that they have learned to associate with a similar sequence. Thus, children who know the label / $\mathrm{ax} /$ for $\langle\mathrm{R}\rangle$ may spell the / $\mathrm{ax} /$ of car as a unit rather than analyzing it into $/ \mathrm{a} /$ and $/ \mathrm{x} /$ and spelling each sound separately. In this section, we will
see that children use the same processes when trying to spell phonemes and phoneme sequences that aren't well-learned labels for letters in the way that /ad/ is for many children. Here, too, difficulties in phonological analysis can lead children to spell sounds incorrectly or to omit them altogether. A number of such errors occur because, after children break up the speech stream into phones, they must identify each phone with a particular phonogram. This requires classification: deciding which phones should be treated as the same and should receive the same spelling. Classifications that don't match those assumed by the writing system can lead to errors, but these errors are principled instead of random.

### 10.4.1 Consonant Cluster Onsets

One unit that is difficult to divide into phonemes is the consonant cluster onset. Many languages have two-phoneme onsets such as /fl/ or /kı/; some also have longer onsets such as $/ \mathrm{spı} /$. Even children who produce these clusters correctly in their own speech may treat them as chunks ( $\sqrt[3]{ } .1$ ) when asked to break up the clusters. This phenomenon has been observed in a variety of languages, including Czech (Caravolas \& Bruck, 1993), Dutch (Bertelson, de Gelder, \& van Zon, 1997; Schreuder \& van Bon, 1989), English (Caravolas \& Bruck, 1993; Treiman \& Weatherston, 1992), French (Morais, Cluytens, \& Alegria, 1984), Spanish (Jiménez González \& Haro García, 1995), and Swedish (Arnqvist, 1992). When asked to delete the first sound of /flos/, for example, English speakers of 7 and 8 years of age often delete the whole onset and say /JI/ rather than /loI/ (Bruck \& Treiman, 1990). Children may do this even after they have completed a series of practice trials designed to demonstrate that just the first phoneme of the onset should be deleted. Many young speakers of English evidently interpret "first sound" to mean the entire onset, and they aren't easily dissuaded from this interpretation.

Children's difficulties in analyzing cluster onsets can make it difficult for them to spell these onsets. US 5 - and 6 -year-olds sometimes produce spellings such as «sid» for slide and <mikeowave> for microwave, symbolizing the first consonant of a two-consonant cluster with the correct letter, or a letter that may represent the phoneme in other words, but failing to symbolize the second consonant (Shankweiler \& Lundquist, 1992; Treiman, 1991, 1993). Both the second and the third consonants of three-consonant initial clusters are susceptible to omission, as in «set» for street and «sceen» for screams (Treiman, 1993). Omissions of the interior consonants of onset clusters have also been reported for learners of Czech (Caravolas \& Bruck, 1993), Dutch (van Bon \& Uit de Haag, 1997; van Rijnsoever, 1979), Spanish (Manrique \& Signorini, 1994) and Thai (Winskel, 2010). Although dropping the interior consonant of an onset cluster often yields a spelling that contains one letter of the correct spelling of the onset, it almost never yields a fully correct spelling.

Most omissions of consonants in onset clusters can't be ascribed to inconsistencies in a writing system. For example, virtually all initial /pl/ clusters in

Czech，Dutch，English，and Spanish are conventionally spelled «pl»．Outside of clusters，the phoneme／l／is spelled with 〈l〉 or 〈ll＞；it is almost never omitted． Thus，it would be difficult to argue that children fail to symbolize the $/ 1 /$ in ／pl／because of exposure to words in which／l／isn＇t symbolized with a letter or because a plethora of spelling options for this phoneme makes them give up the attempt to symbolize it．Nor can one blame the errors solely on the fact that the consonants concerned aren＇t at the beginnings of words．For example， US children are less likely to respond that apron contains $/ \mathrm{I} /$ than that garage contains $/ \mathrm{I} /$ ，even though $/ \mathrm{J} /$ is the third letter and third phoneme of the word in both cases（Treiman，1991）．

Spelling errors such as＜p＞for／pl／reflect the processes of phonological analysis and classification that we have been discussing．When analyzing a word like／ple／for purposes of spelling，a young speaker of English may break it into／pl／and／e／．If the child knows that／e／is the name of＜a＞，she is likely to spell the vowel phoneme with this letter．The child hasn＇t learned／pl／as a label for a letter．However，she may link／p／with＜p＞because／p／appears at the beginning of＜p＞＇s name，because of exposure to words such as papa， because of instruction about the link between／ $\mathrm{p} /$ and $\langle\mathrm{p}$ ，or some combina－ tion of the above．The unit that the child is trying to spell，／pl／，is more similar to $/ \mathrm{p} /$ than to any other phoneme that the child knows how to spell．The child may thus symbolize／pl／with the spelling that she knows to be appropriate for／p／，＜p＞．

Even when children succeed in analyzing an onset cluster into smaller phones，they may not classify those phones into phoneme categories in the same way that the conventional writing system does．Consider the onsets of the English words spill，still，and skill．Literate adults classify the second con－ sonants of these clusters as $/ \mathrm{p} /, / \mathrm{t} /$ ，and $/ \mathrm{k} /$－voiceless plosives．The con－ sonants are conventionally spelled with the letters that normally correspond to voiceless plosives，giving rise to the spellings «sp〉 for／sp／，«st〉 for／st／， and usually＜sc＞or «sk＞for／sk／．However，plosives after／s／aren＇t aspirated； they aren＇t followed by a puff of air．These plosives are in their lack of aspira－ tion similar to the voiced plosives $/ \mathrm{b} / \mathrm{/} / \mathrm{d} /$ ，and $/ \mathrm{g} /$ and different from the word－initial voiceless plosives $/ \mathrm{p} /, / \mathrm{t} /$ ，and $/ \mathrm{k} /$ ．Indeed，when the noise cor－ responding to the initial $/ \mathrm{s} /$ is removed from adults＇or children＇s productions of spill，still，and skill，people report hearing bill，dill，and gill（Hannam，Fraser，\＆ Byrne，2007；Reeds \＆Wang，1981）．Conversely，if noise corresponding to／s／is added to the beginnings of such syllables as bill，dill，and gill，people generally report hearing spill，still，and skill（Sawusch \＆Jusczyk，1981）．

English－speaking children who can analyze onset clusters into phonemes and spell each phoneme separately sometimes use 〈b〉，〈d〉，and 〈g〉 rather than the conventional $\langle\mathrm{p}\rangle$ ，＜t＞，and $\langle\mathrm{c}\rangle /\langle\mathrm{k}\rangle$ for the second elements of initial／s／－plo－ sive clusters．Some US 6 －year－olds spell sky as «sgie»，for example，or report that the pseudoword／spo／should have＜b＞as its second letter（Treiman，1985b， 1993）．Classifying plosives after／s／with the voiced plosives appears to be quite common among children with little knowledge of conventional spelling，as
demonstrated in a study in which Australian 5 －year－olds were shown cards bearing words such as «bit» and «pit» and were drilled until they could pro－ nounce these words confidently（Hannam et al．，2007）．The children were then shown a card bearing the letter＜s＞and were told that they could form spit by placing the $\langle\mathrm{s}\rangle$ before one of the words they had learned，either bit or pit．The children had previously practiced the addition task with easier words，forming a simplified version of see，for example，by adding 〈s〉 to 〈e〉．To form words like spit，the researchers found，children usually chose to add＜ S$\rangle$ to bit rather than to $p i t$ ．That is，the children appeared to classify the initial cluster as more simi－ lar to $/ \mathrm{sb} /$ than to $/ \mathrm{sp} /$ ．Similar results are found for $/ \mathrm{s} /$ clusters in other posi－ tions of words．For example，the phone after the／s／of Casper is similar to／b／ in its lack of aspiration．When writing novel items，English－speaking 7－and 8 －year－olds sometimes spell such phones with letters corresponding to voiced plosives，in situations where adults prefer voiceless plosives（Fink，1974）．

Issues of classification arise also for the initial phone of words like truck．To reduce the distance the tongue must move between the $/ \mathrm{t} /$ and the $/ \mathrm{x} /$ ，speak－ ers of American English tend to position the tongue farther back than usual when pronouncing／t／in this cluster．This results in a sound that approaches or reaches the voiceless affricate $\widetilde{/ \mathrm{t} /} /$ that is heard in Chuck．US children who can spell both phonemes of two－consonant onset clusters sometimes produce spellings such as «chruk＞for truck and «chrie» for try（Read，1975；Treiman， 1985a，1993）．Conventional English never uses «ch＞to spell／t／，but «ch＞is the most common spelling of initial $/ \overline{\mathrm{t} ~} /$ ．Children may have seen «ch in words like chick，may have been taught it as the spelling of $/ \overline{\mathrm{tJ}} /$ ，or both．Errors like «chruk＞for truck thus reflect children＇s reasonable but unconventional classi－ fication of the first phone of the cluster．Errors like «cruk» and «hruk» arise for similar reasons，given that children sometimes remember just one of the let－ ters of a digraph $(\$ 2.4 \cdot 3$ ；see chapter 11）and given that children＇s knowledge of〈H’s name could support its use for／t $\mathrm{t} /$ ．Use of 〈chr〉，«cr〉，and «hr» in place of 〈tr＞has been documented in US children ranging from about 4 to 6 years of age in both naturalistic and experimental studies；a few such errors occur in children as old as 7 （Read，1975；Treiman，1985a，1993）．Supporting the idea that $\langle\mathrm{c}\rangle$ and $\langle\mathrm{h}\rangle$ spellings of $/ \mathrm{t} /$ reflect the affrication that occurs before $/ \mathrm{x} /$ ， these spellings are less common for $/ \mathrm{t}$／before $/ \mathrm{w} /$ or before a vowel．

Children who fail to analyze onset clusters in phonemes for purposes of spelling may produce spellings such as «chuk»，«huk»，or «cuk＞for truck （Treiman，1993）—spellings that deviate to an even greater extent from the cor－ rect «tr＞spelling than do the＜chr＞，＜hr＞，and «cr＞errors just discussed．These spellings reflect children＇s idea that the initial cluster of truck should be classi－ fied as $/ \overline{\mathrm{t}} /$ rather than $/ \mathrm{t}$／for spelling purposes．Children may make similar mistakes on the three－consonant initial clusters of words like string，which one child spelled as «sheg＞（Treiman，1993）．

Analogous phenomena occur with clusters like the one at the beginning of dress．The initial phone of this cluster is normally considered to be the voiced plosive／d／，and its conventional spelling reflects this classification．However，

Americans tend to affricate the phone under the influence of the following $/ \mathrm{x} /$ ，the $/ \mathrm{d} /$ becoming similar or identical to the voiced affricate $/ \widetilde{\mathrm{d} 3} /$ of Jess． US children may classify the initial part of dress as more similar to the affricate than to the plosive and may therefore write «gres» or «jres» for dress（Read，1975； Treiman，1985a，1993）．Both 〈g〉 and 〈j〉 are reasonable attempts to spell／$\overline{\mathrm{d} 3} /$ ． The names of both letters begin with $/ \overline{d_{3}} /$ ，and $/ \overline{d_{3}} /$ is spelled with $\langle g\rangle$ in words like gem and $\rangle$ in words like jump．Children＇s 〈gr〉 and $\langle\mathrm{jr}\rangle$ spellings of the cluster thus suggest that they classify its first element as／$\overline{\mathrm{d}} /$ ．Supporting this view，these spellings are more common for items beginning with／dx／ than with／dw／or single／d／．These errors，like the analogous errors on／t $\mathrm{t} /$ ， have been documented in children of about 4 to 6 years of age；a few are found in children as old as 7 （Read，1975；Treiman，1985a，1993）．Spellings like «ges» or «jes» for dress occur when children treat the onset cluster as a whole，consider－ ing it similar to $/ \widehat{\mathrm{d}_{3}} /$ ．

## 10．4．2 One Versus Two Sounds

Spelling forces children to place phones in one or another category．Errors can arise when children＇s classifications don＇t match those of the conventional writing system．So far we have discussed the classification issues that arise for the phones in clusters．In other cases，the issue is whether a sound should be classified as a cluster or a single sound．Consider the prenasalized consonants of Swahili，which begin with a nasal articulation and end with a voiced conso－ nant，as in the／ gg ／of／ yg urwe／＇pig＇．These consonants are conventionally spelled with $<\mathrm{m}\rangle$ or $\langle\mathrm{n}\rangle$ followed by a consonant letter．That is，the prenasalized consonant is treated as a sequence of two sounds．Young speakers of Swahili sometimes omit the nasal，however，writing such things as «guruwe» in place of the standard spelling ngurwe for this word（Alcock \＆Ngorosho，2003，2007）． Omissions of the nasal are more common than omissions of the following consonant．Children appear to analyze an initial sequence like／ ggu ／into $/ \mathrm{gg} /$ and $/ \mathrm{u} /$ ．Whether they consider $/ \mathrm{gg} /$ a sequence of two sounds or one， they evidently classify it as similar enough to $/ \mathrm{g} /$ to deserve the same spelling． We saw earlier that speakers of languages such as English and Dutch treat a sequence such as $/ \mathrm{gl} /$ as more similar to $/ \mathrm{g} /$ ，its first element，than to $/ \mathrm{l} /$ ，its second element．In contrast，speakers of Swahili treat $/ \mathrm{gg} /$ as more similar to its second element，$/ \mathrm{g} /$ ，than its first element，$/ \mathrm{y} /$ ．The plosive portion of the cluster（ $/ \mathrm{g} /$ ）appears to be a more important determinant of similarity than the nonplosives／ $\mathrm{y} /$ and／ $\mathrm{l} /$ ．

Questions about a one－sound versus two－sound analysis also arise for the affricates $\overline{\mathrm{ts}} /$ and $/ \overline{\mathrm{d}_{3}} /$ of English and some other languages．These begin with a complete blockage of air through the mouth，as for $/ \mathrm{t} /$ and／d／．However， instead of being released as a plosive，the blockage is released as a fricative． From some points of view affricates are two sounds，but from other standpoints the combination is a single sound $\left(\mathbb{\int} 2.2 .2 \cdot 4\right)$ ．The most common English spell－ ings of $/ \overline{\mathrm{d} 3} /,\langle \rangle\rangle$ and $\langle g\rangle$ ，don＇t reflect the sound＇s two－part nature．Likewise，the
most common spelling of $/ \widehat{\mathrm{t}} /$, <ch $\rangle$, doesn't begin with 〈t>. In the middles and at the ends of words, however, some spellings of $/ \overline{d_{3}} /$ and $/ \widetilde{\mathrm{ts}} /$ include $\left.<\mathrm{d}\right\rangle$ and <t>, as in edge, patch, and nature. US 5- and 6-year-olds sometimes produce spellings such as «tekn» for chicken and «dam» for jam (Treiman, 1985a, 1993). These children appear to perceive the similarity between $\widetilde{\mathrm{t} \int} /$ and $/ \mathrm{t} /$ and between $/ \widehat{\mathrm{d}_{3}} /$ and $/ \mathrm{d} /$ and use that similarity to guide their spelling. Spellings of $/ \overline{\mathrm{t}} /$ with $\langle t\rangle$ are more common than spellings of $/ \overline{\mathrm{d}_{3}} /$ with $\langle\mathrm{d}\rangle$, probably because children are less likely to know the conventional spelling of $/ \overline{\mathrm{t}} /$. That conventional spelling is a digraph, «ch», and children tend to learn digraphs relatively late. A child who doesn't know a spelling for $/ \overline{\mathrm{t} \delta} /$ may choose $\langle\mathrm{t}\rangle$ based on the similarity between $/ \widetilde{\mathrm{tg}} /$ and $/ \mathrm{t} /$. The alternative explanation that children use <t> for $/ \overline{t J} /$ because of experience with words like nature seems unlikely for 5- and 6-year-olds given the relative rarity of such words (Treiman, 1985a).

Spellings such as «tekn» for chicken and <dam> for jam suggest that children relate $\widetilde{/ \mathrm{tJ}} /$ to $/ \mathrm{t} /$ and $/ \overline{\mathrm{d}_{3}} /$ to $/ \mathrm{d} /$. However, children don't treat $/ \widetilde{\mathrm{tS}} /$ and $/ \overline{\mathrm{d}_{3}} /$ exactly as they treat two-phoneme sequences like /tw/ and /dw/. The two elements of $/ \overline{\mathrm{ts}} /$ and $/ \widetilde{\mathrm{d}_{3}} /$ are very similar to each other, having the same place of articulation and voicing. Indeed, from a phonetic standpoint, the second elements are the sound made when the tongue is pulled back from the roof of the mouth, making a sound not much different from that made when any plosive such as $/ t /$ is released, just longer and noisier. For these reasons, it may be especially difficult to learn to treat the two parts of affricates as separate sounds. Supporting this view, US 6-year-olds have more difficulty learning to delete /t/ and /d/from the beginnings of syllables starting with $/ \overline{\mathrm{ts}} /$ and $/ \overline{\mathrm{d} 3} /$ than from the beginnings of syllables starting with /tw/ and /dw/ (Treiman, 1985a).

Diphthongs are another case where two sounds behave in some respects like one. In most cases, each vowel in a word belongs to a separate syllable. But in the case of diphthongs, two vowels are packed into the same syllable. The clearest examples of diphthongs in English are /av/ as in out (more precisely, [æu]), /aI/ as in ice, and /دı/ as in opster. In American English as in many other dialects, several other vowels are slightly diphthongized, including /e/ as in ape (more precisely, [eI]) and /o/ as in open (more precisely, [ou]). Children's spellings of diphthongs sometimes reflect this two-part nature. For example, US beginners occasionally use «ao> or «aoo> for /au/ in an apparent attempt to symbolize both elements of the diphthong (Read, 1975; Treiman, 1993). Children also sometimes use «a> alone, symbolizing the first and more linguistically prominent part of the diphthong. The first element of the diphthong is similar to $/ æ /$ and children spell it with the same letter.

### 10.4.3 Final Consonant Clusters

We saw earlier that children sometimes treat onset clusters as units for purposes of spelling. Another type of sequence that children may treat as a unit is consonant clusters in the coda of a syllable. Such clusters typically appear at the end of a word. They often comprise an approximant or nasal phoneme
followed by a plosive，as in words like bulb or bond．Sometimes children treat an approximant or nasal that follows a vowel as if it is part of the vowel rather than part of a coda cluster．For example，Dutch 6－year－olds who are asked to pronounce the separate sounds in syllables such as／brilg／or／tromp／some－ times treat the vowel and the following sound as a unit（van Bon \＆uit de Haag，1997）．Similarly，US 6 －year－olds sometimes judge that／pilt／contains three units of sound，$/ \mathrm{p} /, / \mathrm{Il} /$ ，and $/ \mathrm{t} /$ ，or that $/ \mathrm{p} \wedge \mathrm{mp} /$ consists of $/ \mathrm{p} /, / \Lambda \mathrm{m} /$ ， and／p／（Treiman，Zukowski，\＆Richmond－Welty，1995）．For these children， pump and pup have different vowels；pump doesn＇t contain a consonant after the vowel that pup lacks（Read，1975）．Linguists and psycholinguists have observed that approximants and nasals are more likely to be treated as part of a unit with a preceding vowel than plosives and fricatives are（Selkirk，1982； Treiman，1984b）．Correspondingly，children are more likely to join the approxi－ mant of a coda cluster like／lt／with the vowel than to join the fricative of a cluster like／ ft ／with the vowel．

When spelling syllables that end with consonant clusters，children some－ times omit the first consonant of the cluster，even when they pronounce it accurately．Such errors have been observed in English－speaking children from England（Snowling，1982），Canada（Caravolas \＆Bruck，1993），and the United States（Read，1975；Treiman，1993；Treiman et al．，1995；Zifcak，1984），as well as in speakers of Czech（Caravolas \＆Bruck，1993）and Dutch（van Bon \＆uit de Haag，1997；van Rijnsoever，1979）．Researchers who have examined children＇s spelling of different types of syllable－final clusters have found that approxi－ mants and nasals are more susceptible to omission in the first positions of clusters than are other consonants．Also，children more often fail to spell a nasal when the following consonant is voiceless than when it is voiced，in line with the fact that the nasal phone is usually quite short in the former case．In many dialects of English，in fact，the main difference between bent and bet is that the vowel is nasalized in the first word but not the second．

Misspellings involving final clusters，including 〈brig〉 for the Dutch non－ word／brilg／，«sik» for the English sink，and «bat» for the English bent，reflect the processes of analysis and classification that we have been discussing． A Dutch child who considers／brilg／to contain／Il／or a US child who consid－ ers sink to contain／Ĩ／may not have any ready－made associations that he can use to spell／ $\mathrm{I} / /$ or $/ \tilde{\mathbf{I}} /$. Neither is the name of a letter，for example．However， ／Il／and／$/$／are similar to／I／，which children may associate with «i＞．Children may thus write «brig» for／brrlg／and «sik〉 for sink．The misspelling «bat» for bent suggests an analysis of bent as $/ \mathrm{b} /, / \tilde{\varepsilon} /$ ，and $/ \mathrm{t} /$ ．The nasalized vowel $/ \tilde{\varepsilon} /$ is similar to／e／in many respects．Children who are familiar with the names of letters associate＜a＞with／e／，and they may extend this spelling to the similar vowel／$\tilde{\varepsilon} /$ ．Indeed，one US youngster explained，after writing «bat» for both bent and bet，that the＜a＞of the first word said $/ \tilde{\varepsilon} /$ and that the＜a＞of the second word said $/ \varepsilon /$（Read，1975）．

Many of the phonemes that children tend to omit in the first positions of final consonant clusters，including $/ \mathrm{m} /, / \mathrm{n} /$ ，and $/ 1 /$ ，are spelled quite
consistently in the languages we have been discussing. For example, /l/ is always spelled «l» in Czech. When learners of Czech fail to spell /l/ in a final cluster (Caravolas \& Bruck, 1993), one can't attribute the error to exposure to conventional spellings in which /l/ isn't symbolized or to a plethora of possible phonograms to choose from. That is, children may have difficulties even with phonemes and words that are spelled quite regularly in their writing system.

What is a cluster in one dialect of a language may not necessarily be a cluster in another dialect. For example, most speakers of American English include /l/ in help and /t/ in past, but some African Americans don't. The words don't contain final clusters for them, and their spellings may reflect this. Thus, the African American children in one study who heard the nonwords /tclp/ and /hest/ from a speaker who pronounced the consonant clusters sometimes spelled the items as «tep» and <hes», respectively (Kohler et al., 2007). The children interpreted the nonwords along the lines of their dialect and spelled them accordingly.

### 10.4.4 Other Ambiguities Involving Phonemes

We have been focusing on children's analysis and classification of phones in clusters. Ambiguities may also arise for phones that aren't in clusters. Consider the taps in the American English pronunciations of words such as ladder and latter. When /t/ or /d/ occurs between a stressed vowel (or a vowel followed by $/ \mathrm{x} /$ ) and an unstressed vowel, US speakers generally pronounce it as a quick tap of the tongue tip against the roof of the mouth. The tap assimilates in voicing to the vowels on either side of it, making pronunciation more economical. Is the tap a /d/ or a /t/, or is it different phoneme altogether? The voicing of the tap suggests that it belongs in the /d/ category, and many young children spell it accordingly. Thus they write such things as «sweder> for sweater and «sqrdid» for squirted (Bourassa, Treiman, \& Kessler, 2006; Read, 1975; Treiman, 1993; Treiman, Cassar, \& Zukowski, 1994; Wolter, Wood, \& D'zatko, 2009). Such spellings are incorrect for the majority of flaps, which like these are conventionally spelled as <t>. In the case of taps, unlike in the other cases mentioned earlier, children must learn the conventional classification separately for each morpheme. That is, learning to spell involves some memorization on a word-by-word basis.

The spelling of water as <woodr> includes an unconventional spelling of the final phoneme as well as of the tap. Water ends in a syllabic consonant. Even though a vowel appears in the spelling, it has disappeared from American English pronunciation, leaving the following consonant to fill its role as the nucleus of the syllable. One way of indicating syllabic consonants is to place a vertical bar under the consonant (2). Because / $\downarrow /$ is so common in English, it has a much more familiar alternative representation in IPA, $/ \partial \%$. Because that symbol is more familiar, we use it elsewhere in this book, when we aren't calling attention to its nature as a syllabic consonant.
（2）water／＇war！／＝／＇warə／
her $\quad / \mathrm{h} \mathbf{I} /=/ \mathrm{h} \cdot /$
bird／badd／＝／bəd／
apple／＇æpl／
cotton／＇katn／

In naturalistic and experimental studies，US beginners sometimes spell syllabic consonants，especially $/ \underset{\downarrow}{ } /$ and $/ \mathbb{~} /$ ，using only the letter appropri－ ate for the consonant，as in 〈hr» for her，«woodr» for water，and «apl» for apple （Read，1975；Reece \＆Treiman，2001；Treiman，1993；Treiman，Berch，Tincoff， \＆Weatherston，1993）．Children are less likely to include a vowel in a word like sir than in a word like sip．These findings provide information about chil－ dren＇s implicit judgments of phonological similarity．For example，it appears that children consider $/ \downarrow /$ similar enough to other instances of $/ x /$（as in car） to merit receiving the same spelling．

Effects of similarity are seen in other unconventional spellings as well． Consider a child who knows that $\langle\mathrm{g}\rangle$ is associated with $/ \mathrm{g} /$ but who has trouble remembering a phonogram that is associated with $/ \mathrm{k} /$ ．The child may choose〈 g 〉，which is linked with a phoneme that is like $/ \mathrm{k} /$ in all features except voic－ ing（Treiman，1993）．Children who remember that $\langle\mathrm{u}$＞is associated with／ $\mathrm{z} /$ but who have trouble remembering how to spell／a／may use＜u＞based on the similarity between／$\partial /$ and／$\alpha /$（Table 10．1；Treiman，1993）．The similarity effects that we see in these cases are like those we saw in $\S 10.2$ for letter names．

The similarity between two phonemes may differ according to which dialect of a language one speaks．For example，people from some parts of the United States pronounce the vowel of pen identically to the vowel of pin and the vowel of king similarly to the vowel of key．The spellings of children from these areas appear to reflect this（Treiman，1993）．For speakers of British English，the sec－ ond vowel of visit／＇vizit／is quite similar to the vowel of hit／＇hit／，apart from the difference in stress．For speakers of Australian English，the vowels are less similar：visit is closer to／＇vizət／，with a second vowel that can be spelled multi－ ple ways in English．Consequently，young speakers of British English are more likely than speakers of Australian English to spell the second vowel of visit with ＜i＞（Kemp，2009）．

## 10．4．5 Suprasegmental Features

Particularly difficult for young spellers are suprasegmental features，that is， features like tone or length，which are superimposed on other phonemes （ $\$ 2.2 .2 .5)$ ．Consider Finnish，which has a contrast between long and short pho－ nemes．A long／s：／inside a word is always spelled 〈ss〉，doubling the spelling for the short $/ \mathrm{s} /$ ．Despite the regularity of the pattern，Finnish 7 －and 8 －year－olds sometimes spell a long consonant such as／s：／with a single letter＜s instead of doubling it（Lehtonen \＆Bryant，2004，2005；Lyytinen，Leinonen，Nikula，Aro，
\＆Leiwo，1995）．Difficulties with length distinctions have also been reported among learners of Estonian，which in some cases marks length distinctions by the use of different single－letter spellings，such as «k〉（long）versus 〈g〉（short； Viise，Richards，\＆Pandis，2011）．The length of a phoneme is defined relative to that of other nearby phonemes：The same segment auditorily can represent a long phoneme in some contexts and a short one in other contexts．Moreover， distinctions of length may be erased or distorted when speaking slowly for purposes of spelling．The identity of a phoneme is less likely to be lost．These things mean that children may have some difficulty with spelling distinctions that are based on phonological length even when these distinctions are marked in a very predictable way within a writing system．Indeed，as we saw in $\mathbb{\$ 2 . 5 \text { ，a }}$ number of writing systems don＇t represent length distinctions at all．

The suprasegmental features of stress and tone are，like length，susceptible to loss when analyzing words for purposes of spelling．The representation of stress is completely regular in Greek，where the acute diacritic mark（＇）is placed over the stressed vowel in every word of more than one syllable．Even though this pattern is highly regular，and even though it is explicitly taught in Greek schools，Greek children sometimes fail to include stress diacritics after years of instruction（Protopapas et al．，2013）．Adults often drop the diacritics，too，in electronic communications．Learners also have difficulty marking stress cor－ rectly in Spanish，where an accent mark is required only when the stress can＇t be correctly predicted by a rule based on the phonemic patterns in the word （Defior，Jiménez Fernández，\＆Serrano，2006；Defior，Jiménez－Fernández，\＆ Serrano，2009）．These errors reflect in part the small size of the diacritics，but they also reflect the aspects of phonology that the diacritics represent．

## 10．5 Beyond Phonology

We have focused so far in this chapter on young children＇s use of phonology to construct spellings．According to constructivist and phase theories，in fact， early spelling is based almost entirely on phonology（ $\$ 4 \cdot 3, \$ 4 \cdot 4$ ）．Developmental versions of dual－route theory make the same claim（ $\$ 4 \cdot 2$ ）．The research that we turn to now，however，shows that phonology isn＇t the only influence on young children＇s spelling．Regardless of the writing system they are learning，even young children store information about the spellings of some common and important words．This knowledge helps them to spell those words，and it also influences their spelling of other words．The findings support IMP＇s claim that spelling involves the parallel use of different types of information，both infor－ mation about the spellings of specific words and knowledge of more general patterns．

One word that is particularly important for children，and one that they often learn to write at a young age，is their given name．In one study，US parents who were asked about the first printed word their child learned reported it to be a personal name in over $85 \%$ of cases，most often the child＇s given name
(Treiman, Cohen, Mulqueeny, Kessler, \& Schechtman, 2007). Further evidence for a priority for children's names comes from the finding that Israeli $4^{-}$and 5 -year-olds were more likely to use actual Hebrew letters when writing their given names than when writing other words, and more likely to use correct letters (Tolchinsky-Landsmann \& Levin, 1985). Likewise, Israeli and Dutch 3- and 4 -year-olds were more advanced at writing their given names than at writing other words (Levin, Both-de Vries, Aram, \& Bus, 2005). US children, who are typically called by their given name alone, generally learn its spelling before that of their family name (Hildreth, 1936). In China, in contrast, children are often called by their family name followed by their given name. They are frequently exposed to the characters for both the family name and the given name, leading to similar levels of performance on the two (Yin \& Treiman, 2013).

There are several reasons why children tend to learn about the conventional spelling of their name quite early. One reason is frequency of exposure. Starting as infants and toddlers, children in many societies see the written spelling of their name and hear all or part of its oral spelling. For example, Joe's parents may mount a framed piece of fabric with his name embroidered on it over his crib. They may say such things as "Your name starts with J" (Robins et al., 2013), and they may mention the name when discussing other words as well. For example, a parent may refer to the child's name when reminding him how to form a letter (Levin \& Aram, 2005). Another reason for the name's priority is that people pay special attention to what is important to them personally and tend to remember such information well. A child places special value on her name, just as she values the ragged doll that she owns over the new doll that belongs to another child.

Moreover, children's experiences with their printed names have some special characteristics. Consider the child who sees her name written in small black letters next to her photograph on a bulletin board in her daycare center and who sees a handwritten version of her name on a picture she has drawn, written in red crayon by her teacher. The color and style of the print are different, and the background is different, too, but the child may know that it's her name in both cases. Names differ in this regard from the many signs and logos in which words always appear in the same colors and on the same backgrounds. In the US, for example, STOP typically appears in white letters on a large red octagon on a sign by the side of the road, and CREST is usually in red and blue on a tube of toothpaste or the box in which the toothpaste came. Children often rely on the context rather than the letters to identify environmental print such as this (Masonheimer, Drum, \& Ehri, 1984), but they can't usually do that for their names. Another special characteristic of children's experiences with their own names is that many of them involve production. Children see other people write their name and they attempt to write it themselves. This gives them the opportunity to learn about the order and direction in which the lines and shapes are produced, things that would be difficult to glean from a static form such as CREST.

Some of the special characteristics that we have discussed with regard to children's own names apply to the given names of other people as well. For example, children sometimes write the name of a family member, as on a birthday card, and they see other people write it. In the survey that was mentioned earlier, parents reported that the given names of family members were among the earliest printed words that children learned (Treiman, Cohen et al., 2007). When the names of the children at a childcare center are written on the children's lockers, drinking cups, or other possessions, children may also learn about the spellings of their classmates' names (Levin \& Ehri, 2009; Share \& Gur, 1999).

The results we have been discussing support IMP's claim that children learn about the spellings of specific words as well as about general patterns of their writing system. In particular, young children store information about the written forms of certain common and important words even before they can justify these spellings phonologically. Further supporting this idea, children's tendency to make the phonological errors we discussed earlier in this chapter varies with the familiarity of the words they are attempting. Thus, the US 6 -year-olds in one naturalistic study were almost twice as likely to represent the affrication of /t/ before / $\mathrm{I} /$ when spelling novel items like /tuif/ than when spelling words like truck (Read, 1975). The US 6-year-olds in an experimental study were more likely to spell both consonants of an initial cluster in a phonologically legal manner when writing words like blow than nonwords like /bli/ (Treiman, 1991). Differences between words and nonwords have also been reported for final consonant clusters. For example, US 6 -year-olds sometimes use «n> when writing common words such as and but omit it in other /nd/clusters, such as those in nonwords (Treiman et al., 1995). Children's knowledge about the conventional spellings of certain common words constrains their spelling, helping them to avoid certain errors that they might otherwise make.

The finding that children store information about the spellings of certain words, regardless of their level of skill and regardless of the writing system they are learning, doesn't fit with the developmental version of dual-route theory that was discussed in $\$ 4.2$. Dual-route theory postulates two methods of spelling: a nonlexical route that involves rules that link phonemes to letters and a lexical route that involves a store of memorized spellings. The nonlexical route is thought to dominate for beginning spellers. Use of the lexical route is said to increase with experience, at least for learners of writing systems that dual-route researchers classify as deep. Users of shallow writing systems, such as Spanish, have little need for a lexical route. Even skilled users of such systems are thought to rely heavily or exclusively on the nonlexical route, which yields correct spellings in almost all cases.

Apparent support for the predictions of this developmental version of dual-route theory comes from studies that have failed to find frequency effects (better performance on more common words than on less common words) and lexicality effects (better performance on words than nonwords) in young spellers (Alegria \& Mousty, 1996; Sprenger-Charolles, Siegel, \& Bonnet,
1998). However, the word frequency counts used in these studies were based on reading materials designed for adults. Such counts may not reflect young children's exposure to and interest in written words. Researchers who have selected words based on how often they appear in children's reading books and classroom lessons have found frequency effects in children as young as 6 years of age (Martinet, Valdois, \& Fayol, 2004). Of course, the finding that children spell their own name better than most other words is also a frequency effect, and one that appears as early as 3 or 4 years of age.

Some studies have reported increases in the size of frequency and lexicality effects across the first few years of primary school (Defior et al., 2009, for Spanish; Lété, Peereman, \& Fayol, 2008, for French). These results appear to support the dual-route view that reliance on the lexical route increases with level of spelling skill. However, interpretation of such results is complicated by the fact that, as discussed in chapter 3, skill in a domain generally increases slowly at first and then more rapidly, before starting to level off. For young children, even the most frequent words that are included in an experiment may have not been practiced very often. Differences in performance between high-frequency words and low-frequency words and nonwords may thus be small. At higher levels of skill, the same difference in objective frequency will correspond to a larger difference in performance. Thus, increases in the size of frequency or lexicality effects with experience don't necessarily mean that beginning spellers rely less on the lexical route and more on the nonlexical route than skilled spellers. In addition, the existence of frequency and lexicality effects among learners of Spanish (Defior et al., 2009) and Italian (Cossu, Gugliotta, \& Marshall, 1995) speaks against the idea that users of shallow writing systems use only a nonlexical route. Instead, consistent with IMP, children store information about words' spellings even when they could theoretically construct these spellings without error whenever they need them.

The information that children store about the spellings of certain words can help them to spell those words, and it can also help them to spell other words. Thus, some of the Dutch $4^{1 / 2}$-year-olds in one study appeared to use what they knew about the spelling of their given name when they wrote other words. According to these findings, a girl named Sandra would sometimes correctly use «s in words that have the /s/ sound at a time when she didn't yet use letters other than 〈s> to represent sounds (Both-de Vries \& Bus, 2008). The initial letter of the child's given name was extended first to other words, children being more knowledgeable about it than about later letters in the name. Children younger than around 5 years of age don't always use their knowledge of their own name's spelling when writing other words, though, probably because they tend to treat the spelling of the name as a chunk (Treiman \& Broderick, 1998).

By about 6 years of age, children in several countries show clear evidence of extending what they know about the spellings of words other than their name to new words. Thus, French 6-year-olds who knew that / ліво/ 'syrup' is spelled «sirop» sometimes spelled the nonword /diко/ with final «ор» (Bosse, Valdois,
\＆Tainturier，2003；Martin et al．，2004）．US 6－year－olds who learned to spell the nonword／gark／as 〈giik〉 sometimes used «ii〉 when spelling other non－ words that contained／aI／，especially if they shared a consonant with／gark／as well as the vowel（Bernstein \＆Treiman，2001）．

Children learn not only about the spellings of specific words but also about some of the formal patterns that characterize words＇spellings，including about the frequencies of particular letters and letter sequences．Indeed，as we saw in $\$ 5.2$ ，children begin to learn about such graphic properties even before they use letters to symbolize sounds．As children start to use phonology in their spelling，they continue to use patterns of this type．Support for this claim comes from the finding that US 5 －and 6 －year－olds who include some phono－ logically motivated letters in their spelling often include some phonologically implausible letters too，such as 〈।＞in 〈pelot＞for potato．The implausible letters tend to be one that are common in English，such as «l＞，rather than ones that are uncommon，such as 〈v〉（Treiman，Kessler，\＆Bourassa，2001）．The better performance of Brazilian children on nasalized vowels that are conventionally spelled with a vowel letter followed by «n＞，as in brinco／＇brĩku／＇earring＇，than on those that are conventionally spelled with a vowel letter followed by＜m＞，as in bambu／bã＇bu／＇bamboo＇（Ferreira \＆Correa，2010），may also reflect the chil－ dren＇s knowledge of letter frequency．The former spellings are more common than the latter in Portuguese．

The findings reviewed in this section speak against the idea，which is instantiated in phase theory $(\$ 4.4)$ and developmental versions of dual－route theory $(\$ 4.2)$ ，that young children＇s spellings are motivated only by phonology． In showing that children＇s early spellings are motivated by multiple patterns， both formal patterns and those involving linguistic function，the results are consistent with IMP（\＄4．6）．We present additional evidence for the importance of factors other than phonology in chapter 11.

## 10．6 Teaching

Children learn some things about spelling informally．However，direct instruc－ tion helps them to learn their writing system，as it helps in the learning of other complex systems（chapter 3）．The benefits of direct instruction about spelling are shown by a study in which one group of English－speaking 5 －year－olds was taught some of the skills that are required to spell words．These included ana－ lyzing words into phonemes and linking phonemes to letters．Another group of children spent the same amount of time writing stories and inventing spell－ ings，but without guidance on how to do so．The children in the former group showed more improvement in spelling，as assessed by a standardized test，than the children in the latter group（Castle，Riach，\＆Nicholson，1994）．Similarly， the 5－year－old Hebrew speakers in another study showed more improvement in spelling when they were taught to analyze words into phonemes and link phonemes to letters than when they were shown correct spellings without
such explanations（Levin \＆Aram，2013）．Given that direct instruction about spelling has benefits for children，we discuss in this section what research has to say about the design of such instruction．

Phonics is one common type of direct instruction for young learners of alphabetic writing systems（ $\$ 1.3 .2$ ）．In phonics programs，a small set of cor－ respondences between letters and phonemes is explicitly taught to children． Correspondences in the phonogram－to－sound（reading）direction are normally stressed，on the assumption that children will generalize，or transfer，to the sound－to－phonogram（spelling）direction．A further assumption is that chil－ dren will use the taught correspondences to spell sounds in a variety of posi－ tions and a variety of types of words．For example，it is assumed that English speakers who are taught that $/ \mathrm{m} /$ corresponds to $\langle\mathrm{m}\rangle, / \mathrm{p} /$ to $\langle\mathrm{p}$ 〉，and $/ \mathrm{l} /$ to〈l〉 will use these correspondences to spell pup，pump，and plum．However，the results we have reviewed in this chapter suggest that children don＇t transfer as widely as phonics instruction assumes．Even when two tasks are related， as reading and spelling are，practice in one task doesn＇t show full transfer to the other．Limitations in children＇s phonemic analysis skills also contribute to a lack of transfer in the case of consonant clusters like those of pump and plum．This means that instruction about isolated phoneme－to－phonogram cor－ respondences won＇t necessarily eliminate spelling errors such as＜pup＞for pump and＜pum» for plum．Practice in hearing the difference between the pairs of words or practice in pronouncing the clusters probably won＇t help，either．

Some of the problems just described can be circumvented by teaching chil－ dren to translate from sounds to spellings as well as from spellings to sounds． In addition，the spellings of certain phonological sequences can be taught as wholes．For example，children can be taught that the cluster／pl／is spelled with $\langle\mathrm{pl}>$ rather than being expected to figure it out on their own．Teaching of this sort may also reduce the incidence of errors that reflect plausible but unusual classifications of phonemes．For example，children who are taught ＜tr＞as the spelling of／tı／should make fewer errors like＜chruck＞for truck． Children who are taught «ar＞as the spelling for／ax／should make fewer errors like＜cr＞for car．

Another potential way to increase transfer is to teach children to analyze clusters and other phonologically cohesive units．Such phonological analy－ sis instruction gained popularity in the United States and other countries after studies showed its benefits for spelling and reading（Ehri et al．，2001）． However，it is important that this instruction not go too far．Phonological anal－ ysis is a means to an end，not an end in itself．The goal is to produce writers and readers，not linguists．Children should thus be taught to classify sounds as their writing system does；they shouldn＇t be taught alternative or more detailed analyses．Children should be taught to analyze words into phonemes as a part of spelling and reading instruction，not as an isolated skill．Analysis of spoken words into phonemes is sometimes taught with sounds alone on the idea that using letters would confuse children．However，research sug－ gests that teaching that includes letters is more helpful for spelling（Ehri et al．，
2001), perhaps because the resulting exercises are similar to spelling itself. Phonological analysis instruction should not go on too long, either. Whereas having 5 -year-olds isolate the initial sound of sap /sæp/ may help their spelling, having 10-year-olds say sap backwards-as some programs for teaching spelling do-isn't likely to improve their literacy skills.

In teaching spelling, like other subjects, more time should be spent on harder material than on easier material. If children are familiar with letter names, for example, more time should be spent on the correspondence between « W » and / w/, which is unexpected given the letter's name and consequently harder to learn, than on the correspondence between $\langle\mathrm{p}\rangle$ and /p/. As another example, children who know letter names find the final «e» in words like make and drape difficult. Extra instructional time is needed here as well.

Even with good instruction, children will spell some words incorrectly. The research discussed in $\mathbb{\int} .5$ suggests that errors aren't intrinsically helpful or harmful. What is important is what happens after learners make errors: the feedback that they get. Feedback about errors is especially important for spelling because children don't possess a full list of the written words of their language. When they misspell a word, they often don't know that they have made a mistake. When children decode a word incorrectly while reading, in contrast, they often know that they have erred because the result isn't a word or because it is word that doesn't make sense in context.

Given the importance of feedback in learning to spell, we discuss in some detail a study of French 5 -year-olds that examined its influence (Rieben, Ntamakiliro, Gonthier, \& Fayol, 2005). The researchers found that children who tried to spell words like lit/li/ 'bed' tended to perform better on later spelling tests than children who saw and copied an adult's spellings or who drew pictures, provided that the adult produced and explained the correct spellings of the words after the children had written their own versions. Children who produced spellings without receiving such feedback didn't perform better on later spelling tests than children who drew pictures. These results suggest that generating responses is valuable in learning to spell, as in other domains, as long as corrective feedback is provided.

What kind of feedback helps most? As we saw in $\mathbb{\$ 3} \cdot 5$, simply telling people that they made a mistake isn't very helpful. When a teacher marks $\boldsymbol{X}$ next to misspelled words and $\checkmark$ next to correctly spelled words, children learn which words they got wrong but they don't have the opportunity to learn the correct answers. The findings discussed in $\mathbb{\$ 3 . 5}$ suggest that it is helpful to provide a learner with the correct answer, draw the learner's attention to the part of the correct answer that differs from her own, and explain why the correct answer is correct. In the study with French-speaking 5 -year-olds (Rieben et al., 2005), children in the feedback condition got all three types of information. Soon after a child had produced her own spelling of a word such as lit, the adult wrote the word correctly for the child. The adult explained how the correct spelling differed from the child's spelling and why, drawing the child's attention to the part of the word that she had misspelled. If the child had written 〈li», for
example, the experimenter said that the child had come up with a nice spelling but that in books lit has a <t> at the end that isn't heard.

Is it necessary to include all three of the above components-providing learners with the correct answer, drawing their attention to the part they got wrong, and explaining why the correct answer is correct? Few studies of spelling have tried to disentangle these components in the case of spelling. However, studies suggest that drawing learners' attention to parts of a spelling they got wrong-for example, by circling the letters in red-is an effective component of feedback (Gettinger, 1985). Research from domains other than spelling suggests that learners benefit not only from being told the correct answers but also from being told why the correct answers are correct or being encouraged to produce such explanations themselves. Indeed, explanations were given to the children in the study by Rieben et al. (2005) that we have been discussing.

The timing of feedback is important, not only its content. In the study by Rieben et al. (2005), children saw the correct spelling of the word soon after they had written their own spelling. Was the immediacy of the feedback crucial, or would delayed feedback work as well? As mentioned in $\mathbb{\$ 3} \cdot 5$, classroom studies typically show a superiority for immediate feedback over delayed feedback, in part because learners usually pay more attention to immediate feedback (Kulik \& Kulik, 1988). A study that examined this issue within the context of spelling reported larger gains when children received feedback about their spelling of each word immediately after they produced it-probably the time when they were most interested in finding out the correct spelling-than at the end of a list of words (Harward, Allred, \& Sudweeks, 1994). However, the
 dents are encouraged to attend to it.

An important aspect of feedback is the attitude that it conveys. In the study by Rieben et al. (2005), the adult treated the children's errors as reasonable and logical. However, it can be difficult for literate adults to understand the logic behind some of children's errors. This is because learning the spellings of sounds encourages people to classify them as the writing system does, as we discuss in more detail in chapter 13. Literate speakers of English, teachers included, classify the second sound of spin as /p/ and the first sound of truck as $/ \mathrm{t} /$. They consider the spoken form of pump to contain four sounds, in line with its spelling. Thus, without special instruction, it can be hard for teachers to understand the logic behind misspellings such as «sbin» for spin, «chruk» for truck, or <pup> for pump.

So far, we have assumed that feedback should include the correct spelling of the word. Some researchers have suggested, in contrast, that children should be given a spelling that is moderately more sophisticated than their own, not necessarily the correct spelling. This suggestion stems from Vygotsky's (1978) idea that children understand new ideas that are somewhat more advanced than their current ideas, ones that are inside the zone of proximal development, better than new ideas that are substantially more advanced $(\sqrt{3} \cdot 5)$. These views were implemented in a study with Canadian 5 -year-olds in which an adult provided,
for example，«ekxl» as a spelling of eel after a child wrote＜ekxn»（Ouellette \＆ Sénéchal，2008）．The spelling 〈ekxl» is arguably more sophisticated than the child＇s spelling，in that it has the right final consonant，but it＇s still wrong． Although the children who received this training improved in spelling，we sus－ pect that children who saw the correct spellings would have improved more． Children remember some of the letters and letter sequences they see，and a child who saw＜ekxl〉 for eel might wrongly include 〈k〉 and 〈 x 〉 in later spellings of this or other words．Although even beginners should see correct spellings， in our view，explanations of why a spelling is correct can be tailored to a child＇s level．A child who writes＜ekxn＞for eel could be told that the spoken word ends with／l／and that the spelling should therefore end with＜l＞．The child should have the opportunity to see the two＜e＞s in the conventional spelling，but the adult might not try to explain why there are two＜e＞s rather than one．

Teachers of children who are beginning to spell on a phonological basis sometimes throw up their hands：What was a child thinking when she spelled eel as «ekxn»？The research discussed in this chapter points to something that the teacher can praise－the child＇s use of＜e＞for／i／．Moreover，many spellings that represent just some of the phonemes in a spoken word show substantial knowledge on the child＇s part about the outer form of writing．For example，the child who wrote «ekxn» may have produced letters in the left－to－right sequence that is conventional for English．When giving feedback，teachers can acknowl－ edge the phonological and nonphonological knowledge that a child possesses．

Phonics instruction assumes that memory is important primarily for spell－ ing words that don＇t fit the taught rules，which are often called sight words． However，the research reviewed in this chapter shows that children remember words＇spellings from an early age，both spellings that fit the rules they are taught and spellings that don＇t．The research to which we turn in the next chapter further shows that some so－called sight words actually follow patterns， albeit more complex patterns than those typically taught in phonics programs． Rote memorization is required for some letters in some words in some lan－ guages．However，the number of arbitrary spellings that must be memorized by rote is smaller than often assumed．

## 10．7 Conclusions

Many of children＇s earliest written productions are attempts to reproduce the salient graphic features of the writing they have seen，rather than attempts to symbolize language．We discussed these productions in chapter 5 ．In the pres－ ent chapter，we have looked at more advanced productions，those that attempt to symbolize the sounds of language．We saw that such spellings reflect the use of multiple sources of information，both phonological and nonphonological and both general and specific．Consider Greg，a 6－year－old who wrote sif I had a bac brd I wod fiy no sop a raod the wed＞（＂if I had a blackbird I would fly non－ stop around the world＂）．Greg appeared to have stored in memory the spellings
of some common words, including had, if, and the. He had also learned the spelling of his name, which he placed atop his paper. Greg's phonemic analysis skills were sufficient to allow him to analyze most monosyllabic words without consonant clusters. However, difficulties with clusters contributed to several errors on words whose spellings seem straightforward to adults, including his omission of «t〉 in «sop» for stop and his omission of «n» in «raod» for round. Greg correctly segmented bird /bı̣d/ into three phonemes and chose a plausible but not conventional representation for the / $\downarrow$ /. Other spellings that Greg produced around the same time, including «cak» for cake, showed an influence of letter names.

The constructivist theory $(\$ 4 \cdot 3)$, we have argued, provides a poor description of children's early spellings. For example, many children don't go through a period during which they spell words with the same number of symbols as syllables. Phase theory ( $\$ 4.4$ ) fits the data somewhat better. However, these theories underestimate the nonphonological knowledge that young children possess, including knowledge about the spellings of specific words and knowledge about formal patterns that hold across words. Developmental versions of dual-route theories $(\$ 4.2)$, with their claim that children rely largely on phonology, also underestimate children's knowledge of specific spellings and graphotactic patterns. In addition, these dual-route theories overestimate the importance of regular phoneme-to-phonogram correspondences for young children. IMP $(\$ 4.6)$ acknowledges the importance of both nonphonological and phonological factors in early spelling. Knowledge of common letters and letter patterns and knowledge of whole-word spellings, which begin to emerge even before children start to spell phonologically, don't cease to be influential as children begin to use phonology. Use of phonology in spelling requires linguistic skill, including the ability to analyze spoken words into smaller units and the ability to classify those units in conventional ways. These things can be difficult for young spellers.

We have seen in this chapter that even words with simple one-to-one correspondences between phonemes and letters can cause problems for young spellers. In the next chapter, we turn to spellings that are more complex, including those in which a phoneme is symbolized with a group of letters and those in which a phoneme has several alternative spellings. We discuss the additional challenges that arise in the spelling of complex words, and we consider how children meet those challenges.

## CHAPTER 11 <br> Complex Spellings

the ideal alphabetic writing system, people often think, always spells each phoneme with the same phonogram. No phoneme has a spelling that consists of more than one letter, no group of phonemes has a single-letter spelling, and no letter stands for one phoneme in some words and a different phoneme in other words. Some alphabetic writing systems, such as Finnish and Italian, come close to meeting this ideal. But even they deviate from it in some ways. Other writing systems, including English and French, have many complex spellings. We discussed the nature of those complexities and some of the reasons for them in chapter 2 . In this chapter, we discuss how children learn to spell words that include these complexities.

A number of types of complexities are found in alphabetic writing systems. In some cases, a word has a different number of letters than phonemes. For example, Spanish /'pojo/ 'chicken' has four phonemes but is spelled with five letters, <pollo», because one of the phonograms, <ll», is a digraph. Another type of complexity occurs when the same phoneme is spelled differently in different words. For example, Italian /k/ is usually spelled 〈c> (canto /'kanto/ 'song'), but before the letters «e> or <i> it is spelled «ch> (chiaro /'kjaro/ 'light'). Homophones add additional complications. Not only is there more than one possible spelling of /aI/ in English, there is also more than one possible spelling of /mat//: «mite» and «might». Cases in which two different phonemes are spelled with the same phonogram are another potential source of difficulty. In English, for example, $/ \theta /$ and $/ \overline{/} /$ are spelled alike in words such as thin and then. Homography also occurs at the level of words, as when /wund/ and /waund/ are both spelled «wound». Although syllabic writing systems also include some complexities, in this chapter we focus on alphabets because the large majority of the research has been carried out with learners of these systems.

The prevalence of complexities in certain writing systems has led to the idea that learning to spell in these systems is largely based on rote memorization
$(\$ 4.1)$. However, the rote memorization view overlooks the patterns that exist in even complex writing systems. In many cases, for example, the chance of picking the correct spelling for a phoneme from among several alternatives could be increased by considering the surrounding segments, the graphotactic patterns of the writing system, or the morphological structure of the word. In Italian, for instance, children could choose the correct spelling of $/ \mathrm{k} /$ if they considered the following vowel letter. In English, children could use the fact that $/ \varepsilon /$ is more likely to be spelled as «ea> before /d/ than before other phonemes to help spell words such as head, meadow, hen, and bet. This wouldn't allow them to always choose the correct spelling, as in the Italian case, but it would increase their chances of being correct.

According to the theory that guides this book, IMP $(\mathbb{\$} .6)$, children learn and use many of the patterns that writing systems offer, even when those patterns are complex and even when they don't raise the probability of producing a correct spelling to $100 \%$. By supplementing knowledge of specific spellings with knowledge about writing's general patterns, spellers don't need to rely as heavily on rote memorization. In the sections that follow, we review the research evidence relevant to these claims. Because learning to spell may continue throughout life, especially in complex writing systems, we consider studies of adult spellers as well as studies of children.

### 11.1 Beyond the Dichotomy of Regular Versus Exception Words

Dual-route theory, as discussed in $\$ 4.2$, is associated with the idea that words are either regular or exceptional. A regular word can be spelled correctly using the rules that link phonemes to phonograms; use of these rules constitutes the nonlexical route. When one or more of the phonemes in a word isn't spelled with the most common phonogram, the word is considered exceptional or irregular. To spell such a word correctly, people must use the lexical route. Dual-route theory predicts a regularity effect, namely, that spellers make fewer errors on regular words than on exception words and that they spell regular words more quickly. Many errors on exception words will be regularizations, as in «frunt» for the English front /fuənt/ or «albom» for the French album /albom/.

Dual-route theory assumes that generalizations that go beyond the specific word-rules that links phonemes to phonograms-can't help in spelling the unusually spelled phonemes of exception words. This assumption is sometimes correct. For example, friend, including its derivatives like friendly, is the only English word in which $/ \varepsilon /$ is spelled <ie». There is no general pattern in English spelling that could account for this unusual spelling in this particular word. For a number of words that dual-route researchers classify as exceptional, however, generalizations that go beyond that word could be applied to increase the probability of a correct spelling. Consider the English words in (1), all of which are considered exceptional by dual-route researchers. The
nonlexical route would predict the spellings that are followed by the word not. However, those spellings are improbable on other grounds. These grounds are graphotactic in the first two cases: English words hardly ever end with <v>, and <u» and «w> hardly ever occur next to each other. «Wonder» for wander doesn’t fit a context-sensitive or conditioned rule of English: /a/ is usually spelled «a> after /w/, as in «wand» and «wad». These and a number of other words that dual-route researchers classify as exceptional are thus less exceptional than they first appear.

| (1) /giv/ | give | not giv |
| :---: | :---: | :---: |
| /wok/ | work | not wurk |
| /'wandz/ | wander | not wonder |
| /hed/ | head | not hed |

Words that dual-route researchers classify as regular are also a mixed bag. For example, even though «bed contains the most common phonogram for $/ \varepsilon /$, this vowel has a different spelling in a number of other words, especially when followed by /d/, as in head and meadow. Other words that are classified as regular, including bet, have few such competitors. Studies that pool over words with different characteristics, such as bed and bet, may miss some important differences among them.

As a group, words that dual-route researchers classify as exceptional are indeed harder to spell than words that they classify as regular (Castles, Holmes, \& Wong, 1997, for Australian 7- to 10 -year-olds; Delattre, Bonin, \& Barry, 2006, for French university students; Treiman, 1984a, for US 9- and 10-year-olds; Sprenger-Charolles, Siegel, \& Bonnet, 1998, for French 6-year-olds; Valle-Arroyo, 1990, for Spanish children ranging in age from about 8 to 14). Spellers make more errors on exception words than on regular words, especially when the words don't occur very often in the language, and their errors on exception words are sometimes regularizations. Even when people spell exception words correctly, they may take extra time to do so. The differences between exceptional and regular words show that complex and conditioned patterns are harder to learn and use than simple patterns. They show that patterns that apply to few words are harder to learn than patterns that apply to many words. However, the findings don't show that knowledge that extends beyond a specific word never helps in spelling the problem segments of exception words, as advocates of dual-route theory assume. That theory appears to overestimate the importance of knowledge that is limited to individual words and underestimate the importance of patterns that extend across words. To examine the general knowledge that spellers possess, we must go beyond broad-brush studies that divide words into regular and exceptional categories.

As a first step in this direction, researchers have compared words that contain an unusual phoneme-to-phonogram correspondence-one that occurs in that word and few or no others-to words that contain a correspondence
that，even though unusual，occurs in a number of other words．Friend is an example of the first type of word，in that the correspondence between $/ \varepsilon /$ and ＜ie» occurs essentially nowhere else，and learn is an example of the second type of word，in that $/ \partial /$ is also spelled as＜ear＞in such words as heard and earn． Spellers who were 7 and 8 years old were found to perform better on the sec－ ond type of word than on the first，and they performed best of all on words for which no phoneme has a common alternative spelling（Bruck，1988；Waters， Bruck，\＆Seidenberg，1985）．These results suggest that words within the tradi－ tionally defined categories of regular and exception differ among themselves in the frequencies of their correspondences and that these differences have consequences for spellers．

Based on such findings，a number of researchers have suggested that the frequency of correspondences is a continuum rather than，as dual－route theo－ rists often assume，a dichotomy．The frequency of a phoneme－to－phonogram correspondence can range from high，as with the correspondence between $/ æ /$ and «a in English，to middling，as with the correspondence between／i／ and 〈ea＞，to low，as with the correspondence between $/ \varepsilon /$ and «ai»．The proba－ bility of the least typical correspondence in a word turns out to predict spelling difficulty，above and beyond other factors．Words that are low on this measure， such as said，tend to be hard for children to spell；words that are high，such as stamp，tend to be easier（H．Hayes，Kessler，\＆Treiman，2010，for US children of around 8 years old；Spencer，2007，for English 7－to 11－year－olds）．Likewise， university students are more likely to misspell words with low－probability than high－probability correspondences（Kreiner，1992，Kreiner \＆Gough，1990，for US students；Peereman，Content，\＆Bonin，1998，for French students）．Adults also take longer on words with low－probability correspondences in timed spell－ ing tasks（Kreiner，1992；Peereman et al．，1998）．Other studies show that the probability with which adults spell a phoneme in a nonword with a particular phonogram is related，to some extent，to the frequency of that correspondence in the words of the language．For example，the／aI／－＜i＿e＞correspondence，as in time，is more common in English than the／ar／－〈y＿e〉 correspondence，as in type，and British university students＇spellings appear to reflect such dif－ ferences（Barry \＆Seymour，1988；Burden，1989；Seymour \＆Dargie，1990）． Similar effects have been reported in skilled spellers of Italian（Barry \＆de Bastiani，1997）and Spanish（Cuetos，1993）．The link between people＇s spelling choices and the frequencies of the phoneme－to－phonogram correspondences in the language is far from perfect，however．

The measures of phoneme－to－phonogram correspondence frequency that were used in most of the studies just described didn＇t consider the phonemes＇ context．For example，there was one value for the frequency of the correspon－ dence between $/ \varepsilon /$ and «e＞in English and another value for the frequency of the correspondence between $/ \varepsilon /$ and «ea»．According to such a measure，«e» is a more common spelling of $/ \varepsilon /$ than «ea＞is．However，the frequency of a correspondence may vary as a function of the neighboring segments，the mor－ phological structure of the word，or other factors．In English，for example，$/ \varepsilon /$
is less likely to be spelled as «e» before /d/ than before other consonants and more likely to be spelled as <ea>. Several studies of children in their first year of formal literacy instruction found that, although measures that don't take context into account helped to predict spelling accuracy, measures that considered context made no additional contribution (Lété, Peereman, \& Fayol, 2008, for French children; Treiman, 1993, for US children). Context-sensitive measures did make an additional contribution to the prediction of spelling performance in children who were completing at least their second year of formal literacy instruction (Lété et al., 2008, with French children) and in adults (Perry, Ziegler, and Coltheart, 2002b, with Australian university students). That is, the ability to use context to help in choosing among spellings of phonemes appears to develop over the first several years of formal literacy instruction.

At first glance, these findings fit well with the phase theory of spelling development ( $\$ 4 \cdot 4$ ). According to phase theory, less experienced spellers-those in the partial alphabetic and full alphabetic phases of spelling developmentdon't consider a phoneme's context or morphological status when selecting a spelling for it. Nor do they consider the graphotactic legality of the resulting spelling. Children begin to use conditioning factors when they enter what is called the consolidated alphabetic phase. According to phase theory, the ability to use different types of conditioning factors, including phonological context, morphology, and graphotactics, develops around the same time. The studies using context-sensitive measures that we have discussed so far grouped together different types of conditioning factors. Thus, the studies don't provide a good test of whether the ability to use different sorts of conditioning factors emerges at a single point in development, as phase theory predicts. In the sections that follow, we discuss studies that have separately examined different sorts of conditioned patterns. We will see that the children learn about some conditioning factors, especially simple graphotactic ones, rather early-earlier than phase theory suggests. Other conditioned patterns are learned much later.

### 11.2 Conditioning by Neighboring Segments

In many alphabetic systems, a certain spelling of a phoneme is likely to occur when the phoneme is preceded or followed by a certain segment. Another phonogram is more common when the phoneme is preceded or followed by another segment. In this section, we review the research on whether children use surrounding context to help select among spellings and when and how they learn to do so.

Before addressing our questions about children's spelling, it is important to discuss why conditioned patterns are so common across writing systems. One reason, as discussed in $\mathbb{\int} .8$, is that pronunciations change over time. Spellings, being more conservative than pronunciations, are often not updated to reflect these changes. A number of sound changes, when they occur in the absence of spelling change, result in what are interpretable as conditioned
spellings. For example, the vowel of English fall was originally the same as that of fat, but it changed under the influence of the following $/ l /$. The spellings didn't change. As a result, fall now has the same vowel phoneme as flaunt in many dialects of English, /د/, but a different vowel spelling. For the modern speaker of English, the spelling of $/ \mathrm{J} /$ is associated with or conditioned by the following consonant. Whereas <au» is the most common spelling of $/ \mathrm{J} /$ in all contexts combined, «a> is commonly found in words with a following <l>, like fall. Other cases of conditioning by a neighboring segment are best understood as occurring for graphic reasons. For example, English has few words with <u> before «v». The reluctance to write «uv> helps to explain the use of «o> where «u» would otherwise be expected, as in love and shove. This pattern applies regardless of the phonemes that $\langle u\rangle$ and $\langle\vee\rangle$ represent.

Whether a conditioned rule originated in a sound change or for graphic reasons, people could conceptualize the rule either phonologically-/o/ is more likely to be spelled as «a> before /l/ than before other phonemes-or graphically-/ / is more likely to be spelled as «a» before «l> than before other letters. We adopt the convention of describing the conditioning context phonologically. However, we don't wish to prejudge the issue of whether children learn patterns on a phonological basis or a graphic basis, and we discuss studies that have attempted to disentangle the possibilities.

The way in which children learn about context-conditioned spelling may depend on the particular type of conditioning involved. In what follows, therefore, we consider different types of conditioning according to the phonemes involved and their positions in the syllable. We begin with a common type of context-conditioned pattern, one in which the consonantal portion of a syllable that follows the vowel, the coda, influences the spelling of the preceding vowel.

### 11.2.1 Coda-to-Vowel Conditioning

Coda-to-vowel conditioning is a major consideration for English, with almost all English vowels showing some associations of this type (Kessler \& Treiman, 2001). Several of the previously mentioned cases, including that of $/ \mathrm{J} /$ before $/ l /$ and $/ \varepsilon /$ before $/ d /$, are coda-to-vowel effects. In these cases, as in many others, the environments that are associated with different spellings are often rather specific. For example, the distribution of spelling options for $/ \varepsilon /$ before $/ t /$ differs from the distribution of spelling options for $/ \varepsilon /$ before $/ \mathrm{d} /$, even though /t/ and /d/ are phonologically similar.

Researchers have found associations between the spelling of a vowel and the identity of the coda when scrutinizing the sound-to-spelling relationships of a language, but do everyday people take advantage of these associations? Young spellers of English don't appear to use coda-to-vowel associations. Supporting this view, a context-free measure of correspondence frequency helped to predict the vowel spelling performance of British 5 - and 6 -year-olds, but a measure that took the coda into account didn't improve the prediction (Caravolas, Kessler, Hulme, \& Snowling, 2005). Further evidence that young children don't
benefit from coda-to-vowel associations comes from studies in which children are asked to spell the vowels of such nonwords as $/ \mathrm{kled} /$ and $/ \mathrm{kleb} /$. If children's choices are driven by the probability of spellings pooled across contexts, then children should use «e» more often than «ea> for both /kled/ and /kleb/. This is because the $/ \varepsilon /-<$ e> correspondence is more frequent overall than the $/ \varepsilon /-<e a>$ correspondence. If children's choices are influenced by the following consonant, then they should produce more «ea> spellings for items like /kled/ than for items like $/ \mathrm{kl} \mathrm{\varepsilon b} /$. This is because the $/ \varepsilon /-$ <ea> correspondence is more common before /d/ than before /b/. In one study, US children below about 8 years of age didn't show influences of the following consonant in their spelling of $/ \varepsilon /$ and of other vowels. This was true even though the spellings of these vowels were affected by the following consonant in reading materials targeted at children and in the words of English as a whole (Treiman \& Kessler, 2006). Children's vowel spellings began to be influenced by the following consonant around the age of 8 . This occurred even though children don't normally receive explicit instruction in school about the conditioning factors that were examined in the study. The effects of context reached a maximum around the age of 11. These results show that older children don't always proceed phoneme by phoneme from the beginning of a word to the end, the sort of serial processing envisaged in dual-route theories. In some cases, older children consider the upcoming consonant in deciding how to spell a vowel.

Studies with older children and adults show coda-to-vowel influences in the spelling of nonwords: more <ea> spellings of $/ \varepsilon /$ in $/ \mathrm{kl} \varepsilon \mathrm{d} /$ than $/ \mathrm{kl} \mathrm{\varepsilon b} /$, for example (Treiman \& Kessler, 2006; Treiman, Kessler, \& Bick, 2002). Such influences are also found in the spelling of words. For example, adults are more likely to produce misspellings such as «shread> for shred than «treak> for trek. Evidently, use of «ea> is encouraged by a following /d/ (Treiman et al., 2002). Dual-route theory predicts that people shouldn't use the exceptional <ea> in place of the regular «e» and that «ea> errors shouldn’t occur more often with a word like shred than with a word like trek. The results of these studies don't support the dual-route predictions.

Some connectionist theorists ( $\$ 4.5$ ) see people as ideal statistical learners who internalize the patterns in the written words to which they are exposed (G. D. A. Brown \& Loosemore, 1994). However, the influence of the coda on university students' spelling of vowels can be rather small (Barry \& Seymour, 1988; Perry \& Ziegler, 2004; Perry, Ziegler, \& Coltheart, 2002a). Even after years of experience, spellers of English are less influenced by the following consonant than would be expected given the strength of the patterns in the writing system (Treiman et al., 2002). For example, about half of the monosyllabic English words with the vowel /aI/ and the coda /t/ are spelled with <igh>, as in night and flight. University students are more likely to use the <igh> spelling when /ai/ precedes /t/ than when it precedes other consonants, showing that they are influenced by the coda to some extent. However, adults use «igh> about a quarter of the time before $/ \mathrm{t} /$, not half the time. These results suggest that adults' vowel spellings are motivated primarily by the vowel phoneme. Adults
make some adjustments in consideration of the coda，but they don＇t adjust as much as would be expected based on the patterns in the language itself．

## 11．2．2 Onset－to－Vowel Conditioning

We turn now to cases in which the onset influences the spelling of the fol－ lowing vowel．Many of these cases reflect assimilatory sound change that occurred in the absence of spelling change $(\mathbb{\$} 2.8)$ ．A sound is more likely to change under the influence of the following segment than the preceding seg－ ment，and so we would expect onset－to－vowel conditioning to be less common than coda－to－vowel conditioning．That appears to be true for English，the only writing system where this matter has been studied quantitatively（Kessler \＆ Treiman，2001）．Even so，sound change in the absence of spelling change has sometimes led to what is now interpretable as onset－to－vowel conditioning．For English，one such case involves the vowel of words like wad and swan，which was originally pronounced like the vowel of pad．The influence of the preced－ ing／w／changed the vowel of wad and swan so that it was the same as that of pod，／a／in many dialects of English．The words＇spellings remained the same． The most common spelling of／a／，pooling across contexts，is now «o〉．After $/ \mathrm{w} /$ ，though，this vowel is often spelled as «a»．Other onset－to－vowel influences reflect graphic factors．For example，English resists placing «u» and «w〉 next to each other，as mentioned in $\int 11.1$ ．Vowels that might normally be spelled with «u» are often spelled in a different way after «w»，as in «work» as opposed to «wurk〉．

Adult spellers of English are influenced by several cases of onset－to－vowel conditioning that exist in the language．For example，they are more likely to spell the vowel of a nonword like／gwat／with＜a＞than to spell the vowel of a nonword like／kıat／with «a＞（Perry \＆Ziegler，2004；Treiman et al．，2002）． Adults sometimes misspell a word like wok as＜wak»，in line with the fact that ／a／is often spelled as＜a after／w／．They are less likely to misspell／ $\mathrm{d} / \mathrm{as}$ «a in a word like possum，which doesn＇t have／w／in the onset（Treiman et al．，2002）． The effects of context are smaller than one would expect given the patterns in the spelling system itself，as also observed for coda－to－vowel associations．

In one study，US children younger than around 8 years of age honored some onset－to－vowel associations，although they didn＇t honor any of the coda－to－vowel associations that were tested（Treiman \＆Kessler，2006）．The onset－to－vowel association that children learned first，by around 7 years of age，originated in the aforementioned graphic convention that English resists adjacent «w $\langle$ and 〈u〉．Even 7 －year－olds tended to avoid spellings like＜wurb＞ for／wərb／，which would begin with «wu〉，while producing some spellings like＜slurb＞for／slə＇b／．The children＇s avoidance of spellings like＜wurb＞sug－ gests that children learn about certain graphotactic patterns at an early age． Graphotactic patterns involving letter sequences at the beginnings of words may be learned especially early because children tend to pay special attention to the beginnings of words．

Children eventually learn about coda－to－vowel and onset－to－vowel associa－ tions that must be conceptualized phonologically，but it takes time for them to do so．One example of a rule that must be phonological and not graphic involves $/ \varepsilon /$ before $/ \mathrm{d} /$ and $/ \mathrm{p} /$ ．If spellers avoid «ea＞spellings of $/ \varepsilon /$ with non－ words like／vep／but use «ea＞with nonwords like／ved／，a graphotactic expla－ nation won＇t suffice．Spellings with «ea» are actually more common before／p／ than before／d／in English，with «ea＞representing／i／when it occurs before $/ \mathrm{p} /$ ．On graphotactic grounds alone，one would expect use of «ea＞to be more common before／p／than before／d／．However，adults use＜ea＞more often to spell $/ \varepsilon /$ before $/ \mathrm{d} /$ than before $/ \mathrm{p} /$ ，showing that they are driven by the phonological context rather than by the appearance of the resulting sequence （Treiman et al．，2002）．For many other coda－to－vowel and onset－to－vowel pat－ terns，though，adults may rely on graphotactics．For example，they may learn that＜ighb＞and＜ighp» aren＇t legal letter sequences of English，whereas＜ight＞is．

Graphotactic considerations are particularly important when people have the opportunity to read complete spellings that are written down． When shown «skoaf» and «skofe» and asked which one looks more like a word of their language，English－speaking adults show a small preference for «skoaf»（Perry et al．，2002a）．Indeed，«oa＞is more common before＜f＞ than before most other letters．When asked to write／skof／with the first spelling that comes to mind，however，adults are more likely to write «skofe＞ than «skoaf»．The results of the two tasks may differ because people some－ times decide to use＜o＞followed by final «e» for／o／without considering how that spelling will mesh with an upcoming $\langle\mathrm{f}\rangle$ ．Thus，they may write «skofe» for／skof／even though，when shown «skofe» together with «skoaf»， they consider＜skoaf＞to look better．People don＇t spell purely phoneme by phoneme，as the influences of following context show，but they don＇t always plan an entire spelling before producing it，either．

## 11．2．3 Vowel－to－Onset Conditioning

For English，the language in which context conditioning has been most stud－ ied，vowels have more spelling options than do consonants．Spellers would benefit considerably if they could use a vowel＇s context to help spell it．However， some consonants have several common alternative spellings as well．In some of these cases，knowledge about the following vowel could theoretically reduce the uncertainty in spelling the consonant．For example，initial $/ \mathrm{k} /$ may in English be spelled «c〉，as in cat，cop，and cup，or 〈k »，as in kept and kit．The spell－ ing depends on the following vowel．The pattern may be described phonologi－ cally—initial／k／is normally spelled as «c» before／æ／，／a／，and／ə／but as «k＞ before $/ \varepsilon /$ and $/ \mathrm{I} /$ ．The pattern may also be described graphically－«c＞is more common than «k＞before «a〉，＜o〉，and＜u〉，whereas $\langle\mathrm{k}\rangle$ is more common than〈c〉 before «e〉 and 〈i〉．The graphic description provides the better explanation for the patterns of the language，due in large part to fact that words like／keı／ care are generally spelled with «c〉，as the graphic description predicts，rather
than with «k»，as the phonological description predicts（H．Hayes，Treiman，\＆ Kessler，2006）．Children appear to learn about the effect of the vowel on the spelling of the onset at an early age．The 7 －to 8 －year－olds in one study produced many more «k＞spellings of initial／k／in nonwords like／kisp／than nonwords like／kasp／（H．Hayes et al．，2006）．Indeed，the children showed an effect of context that was as large as that shown by university students．As in the case of $\langle\mathrm{w}\rangle$ before $<\mathrm{u}\rangle$ that was mentioned previously，early learning of a pattern may reflect the fact that it may be understood in terms of graphic constraints involv－ ing the first two letters of a word．Still，neither children nor university students used the pattern as much as expected given its strength in the language．They sometimes produced spellings like＜kosp＞even though English has very few words of this type．

French，like English，has some cases in which the spelling of an onset is influenced by the following vowel．For example，the vowel decides between «qu〉 and «c〉 spellings of／k／and between 〈g＞and «gu〉 spellings of／g／（2）． The rules are formally similar in the two cases，but children use the follow－ ing vowel at a younger age in the case of $/ \mathrm{k} /$ than in the case of $/ \mathrm{g} /$（Alegria \＆Mousty，1996）．The difference probably reflects the fact that spellings with initial «gu» are much less common than spellings with initial «qu»． Frequency of exposure to words exemplifying a pattern is an important determinant of learning．
（2）$/ \mathrm{k} /$ café question quiche coup cuisine
／g／garage guerre guide gorge guttural

## 11．2．4 Vowel－to－Coda Conditioning

We turn now to cases in which the spelling of a coda consonant is con－ ditioned by the preceding vowel．Several letters in English have special extended spellings at the end of some words（3）．For example，／f／in English is normally spelled as＜f〉，but in many words such as riff，staff，off，and stuff，it takes on a longer spelling，〈ff〉．Similar alternations occur for $/ \overline{\mathrm{t}} /, / \mathrm{k} /, / \mathrm{l} /$ ， and，with an extra complication having to do with the use of silent «e»，also with $/ \overline{\mathrm{d} 3} /$ and $/ \mathrm{s} /$ ．Thus this pattern is broader than some of those we have discussed so far．The extended spellings（last example in each row）could be described on phonological grounds：They appear after the vowel sounds traditionally called short vowels，provided there is no other consonant in the coda．An alternative explanation is graphic：An extended consonant is used if there is only one other letter in the rime spelling．The graphic descrip－ tion provides a better explanation of the patterns in the language itself．For example，deaf／dcf／is spelled with an unextended «f $\rangle$ because the preceding vowel is spelled with two letters．If the consonant spelling were based on the pronunciation of the vowel，it would be spelled with an extended 〈ff〉，as in Jeff（H．Hayes et al．，2006）．

| (3) $/$ /f/ | reef | rife | rift | riff |
| :---: | :--- | :--- | :--- | :--- |
| $/ \overline{\mathrm{Tf} /}$ | beach |  | filch | hitch |
| $/ \mathrm{k} /$ | peek | poke | punk | peck |
| $/ 1 /$ | cool | coke | colt | cull |
| $/ \overline{\mathrm{d} 3} /$ |  | stooge | bilge | badge |
| $/ \mathrm{s} /$ |  | louse | long | less |

When adults spell a coda in a single-syllable nonword, they are more likely to use an extended consonant after a short vowel, which they generally spell with a single letter, than after a long vowel, which they normally spell with two letters (H. Hayes et al., 2006; Perry et al., 2002b). Children as young as $7-8$ years of age are also influenced by the preceding vowel, even when the pattern hasn't been taught to them explicitly in school (H. Hayes et al., 2006). The vowel-to-coda effect increases with experience, but even 10 - and 11-year-olds don't show adult levels of context use. Children appear to interpret the consonant extension pattern graphically rather than phonologically, for it is the number of letters that children use to spell the vowel and not the vowel's phonological category that predicts their use of an extended consonant. That is, children appear to learn that words may not end with sequences such as «eaff» but may end with sequences such as «eff» and «aff〉.

Graphotactic considerations are particularly important when people see complete spellings that are written down and take time to consider them. When asked to produce spellings for nonwords, the children and adults in one study were more likely to use an extended spelling for the coda of a nonword like /væf/ than a nonword like /vef/ (H. Hayes et al., 2006). These same children and adults were even more likely to choose an extended spelling of the coda when they were shown two options, such as «vaff» and <vaf», and were asked which one looked more like a word. These results suggest that people have some knowledge about common and uncommon spelling patterns that doesn't always emerge when they produce spellings. When people produce a spelling, as we suggested in $\int 11.2 .2$ for the case of spellings like <skoaf» and <skofe», they don't always consider how a letter meshes with the one that they wrote previously or the one that will come next.

### 11.2.5 Do Rimes Have a Special Status?

Using a vowel to help spell a following consonant involves using one part of a rime to spell another part of the rime. Using a coda to help spell a preceding vowel also involves using one part of a rime to spell another part of a rime. By around 8 years of age, learners of English are more likely to produce correct spellings of words whose rimes have a single dominant spelling (e.g., mouse, file) than words whose rimes have two or more common spellings (e.g., train, where the rime is spelled differently in lane; Nation, 1997; Weekes, Castles, \& Davies, 2006). However, the findings we have reviewed shows that children aren't limited to rimes. They also learn about associations between adjacent
segments that cross the onset-rime boundary within a syllable: onset-to-vowel associations and vowel-to-onset associations. Children learn about associations that cross the onset-rime boundary sometimes even before they learn about associations within the rime. That is, even when associations within the rime are common in a language, as they are in English, children aren't limited to these associations.

As mentioned in $\$ 4.2$, some studies within the dual-route framework suggest that rimes have a special status and that children tend to treat them as unanalyzed units. Studies within the connectionist framework, similarly, often grant rimes a special status. Researchers working within these frameworks sometimes classify words based on the consistency of their rime neighborhoods, or the degree to which other words with the same phonological rime have the same rime spellings. For example, the American English rimes /and/ and /amp/ are somewhat inconsistent because, although they are usually spelled as «ond» and «omp», they are spelled as «and» and «amp» in words like wand and swamp. The results we have reviewed suggest that this inconsistency may not hurt spellers very much because it is rationalized by the onset. Measures of the predictability of sound-to-spelling mappings that are based only on rimes (Ziegler, Jacobs, \& Stone, 1996; Ziegler, Stone, \& Jacobs, 1997) are limited in their ability to account for spelling performance because spellers, from an early age, aren't sensitive only to rimes.

### 11.2.6 Extended Spellings of Intervocalic Consonants

In the final positions of English words, as we have discussed, certain consonants may receive extended spellings after short vowels. Thus, English <pill> has an extended consonant after a short vowel. However, the spellings of most consonants aren't extended in the final position of words. For example, cat, lab, and pan don't have extended consonants. When an unstressed vowel follows the consonant, however, a number of consonants are often extended after short stressed vowels. Thus, English has latter and comma, where the vowel of the first syllable is short, and later and coma, where the vowel of the first syllable is long. Other Germanic writing systems show similar patterns. For example, Dutch has komma 'comma' with a short stressed vowel / $\mathrm{J} /$ in the first syllable and coma 'coma' with a long stressed vowel /o:/ in the first syllable. This pattern was inspired by the fact that at one time there was a rule that short stressed vowels could occur in the middle of a word only before two consonants, including double consonants like $/ \mathrm{mm} /$. Later, double consonants came to be pronounced the same way as single, short consonants in many Germanic languages. However, doubled consonant spellings remained as a graphic device for indicating short vowels.

Surveys of spelling errors in several Germanic languages have uncovered many problems involving the spelling of medial double consonants (Booij, Hamans, Verhoeven, Balk, \& van Minnen, 1979, for Dutch; Yannakoudakis \& Fawthrop, 1983, for English). Indeed, Norwegians have called the double
consonant the most expensive letter combination in their language because it consumes so much time and effort at school (Hagtvet, Helland, \& Lyster, 2005). Experimental research confirms the difficulty of medial consonant extension. In one study, it was not until about 12 to 13 years of age that Danish children doubled consonants more than half the time in the appropriate positions of nonwords (Juul \& Sigurdsson, 2005). Norwegian 9-year-olds who doubled consonants after short vowels when spelling words and nonwords-a number of children of this age never doubled in the case of nonwords-paused for a longer than normal time before writing the first consonant, suggesting continued difficulty (Uppstad \& Solheim, 2007). In another study, US children below the age of 12 performed at the level expected by chance when they heard a pronunciation such as /'tebif/ or /'tibif/ and had to pick the spelling that went with it, «tebbif» or «tebif» (Cassar \& Treiman, 1997). This was true even though children are sometimes explicitly taught to double consonants after short vowels. The poor performance of the US children in choosing a spelling that matched a pronunciation was striking in light of their good performance in tasks that tapped knowledge of graphotactic patterns. Starting around the age of 6 , US children showed some knowledge that spellings with doubled consonants are less probable than spellings with single consonants. Indeed, a study reviewed in chapter 5 suggests even 4 - and 5 -year-olds who don't yet symbolize phonology in their spelling tend to avoid doubled letters (Pollo et al., 2009). One reason that the consonant extension pattern is difficult to learn, therefore, is that it requires children to use a type of spelling that is normally uncommon. Learning to use «bb> after a short vowel in rubber, for example, requires overcoming the knowledge that doubled consonants are much rarer than the corresponding single consonants.

In some cases, learning to use an extended consonant spelling after a short vowel requires children to overcome another pattern that we discuss in more detail in $\mathbb{\int 1 1 . 5}$ : a tendency to spell morphemes in a consistent manner. For example, Dutch kat 'cat' ends with a single consonant letter. If a suffix that starts with a vowel is added, the final consonant is now in a context in which doubling occurs, as with katten 'cats'. Children's tendency to spell a root morpheme in a consistent manner may encourage errors like «katen». A similar example is English drum, which becomes drummer when eer is suffixed. Children make errors like <drumer> for drummer more often than they make errors like <hamer> for hammer (Deacon, Leblanc, \& Sabourin, 2011). The difficulty with drummer reflects conflicting patterns: Contextual patterns involving phonology point to <drummer» but morphology points to <drumer> (i.e., root «drum> followed by suffix -er). Graphotactic knowledge points to <drumer> too: «mm» is less common than «m». Misspellings like «drumer» suggest that the contextually driven phonological pattern sometimes loses out. The results support IMP's view that children use multiple patterns and so may have difficulty when different patterns suggest different spellings ( $\mathbb{4} 4.6$ ).

The consonant extension pattern applies after stressed vowels; extension is rather unpredictable when the preceding vowel is unstressed. For example,

Danish has many words with an unstressed first syllable and a medial double consonant, as in ballon 'balloon', and many words with an unstressed first syllable and a medial single consonant, as in banan 'banana'. The extension pattern becomes apparent only when words in which the preceding vowel is unstressed are factored out. Distinctions of stress are often lost when saying words and sounds slowly for purposes of spelling, however. This may make it hard for children to compute separate statistics for words with stressed and unstressed first syllables, and it may be another reason for the difficulty of consonant extension.

Decisions about consonant extension sometimes depend on the identity of the consonant. Extension rarely or never applies to certain consonants, including English /v/. The explanation here is graphic: The sequence <vv> rarely occurs in languages that use the Latin alphabet. Also, the normal pattern doesn't apply to $/ \mathrm{r} / \mathrm{in}$ a number of Germanic languages, the distinction between long and short vowels having disappeared in this context. Such things wouldn't cause difficulty if children learned a separate rule for each consonant. As we will see, however, they often attempt to generalize.

Yet another difficulty is that the sets of vowels that behave alike for purposes of consonant extension aren't natural phonological categories in some of the languages we have been considering. In English, the so-called short vowels aren't all phonologically shorter than the so-called long vowels and the phonological relationship between the vowels in a pair isn't the same for all pairs (Table 10.1). For other languages, including Danish, the sets of vowels are phonologically well defined: Long vowels are phonologically long and short vowels are their phonologically short counterparts. Even still, length is a suprasegmental feature. Like stress, it may be lost when saying words slowly for the purposes of spelling.

A final reason for the difficulty of the consonant extension pattern is that the pattern has exceptions in some of the writing systems we have been discussing. For example, double consonants would be expected in the English words lemon /'lemən/ and leper /'lepr\%. In Danish, the st> of the common word otte /o:tz/ 'eight' doubles even though the preceding vowel is long.

### 11.2.7 Summary of Results on Conditioning by Neighboring Segments

The results we have reviewed show that experienced spellers sometimes consider the identity of a neighboring segment when deciding how to spell a phoneme. They aren't limited to simple unconditioned rules of the type often put forward by dual-route theorists. The results further show that experienced spellers sometimes consider the identity of an upcoming segment as well as the identity of a previous one. That is, spelling isn't a serial, phoneme-by-phoneme process. However, learning to use context takes time. Even people who have a decade or more of experience with a writing system don't always consider neighboring segments as much as would be expected given the patterns in the
writing system itself．That is，people aren＇t the perfect statistical learners that some connectionist theorists take them to be（G．D．A．Brown，1998）．

There are several reasons why the conditioned patterns we have discussed tend to be learned slowly and incompletely．One reason is that，even in a writing system in which consideration of neighboring segments sometimes helps in selecting spellings，it doesn＇t always help．When context does help，it is some－ times the following segment that is important，sometimes the preceding seg－ ment，and sometimes both．These considerations encourage people to focus more on the phoneme they are trying to spell than on the segments around it． Phonics instruction，with its stress on unconditioned links between phonemes and phonograms，may strengthen this tendency to attend to single phonemes and may work against the use of conditioned patterns，which require people to consider more than a single segment．Further militating against the use of adjacent segments，people＇s attention is rather narrow when they write．Even when people know that the appropriateness of a letter choice depends on the preceding or following segment，they may not always consider the context． Moreover，many contextual patterns apply to a relatively small set of words．

The findings we have reviewed suggest that children are faster to learn about conditioning by a neighboring segment when a simple graphic pattern will suffice than when phonology must be considered．We will see further evi－ dence for an early sensitivity to certain simple graphic patterns in the next section．

## 11．3 Conditioning by Position

When a phoneme corresponds to more than one phonogram，the distribution of the alternatives may differ depending on the neighboring segments，as we discussed in the preceding section．In English，for example，／f／is spelled as〈ff〉 under particular conditions，ones that involve the presence of certain pre－ ceding vowels．Word－initial／f／can＇t fit the conditions，by definition，and so extended spellings of／f／never occur at the beginnings of words．The effect of position may be described phonologically：The correspondence from／f／to 〈ff〉 may not occur at the beginning of words．The effect of position may alterna－ tively be described graphically：«ff〉 may not occur at the beginnings of words． In this section，we review the research on children＇s knowledge of positional constraints．

US children learn at an early age about the ban against certain initial sequences，such as 〈ff〉 and «ck»，and they probably do so on a graphic basis． Whereas US 5 －year－olds are as likely to use a double consonant to spell the first consonant as the last consonant of a nonword（Cassar \＆Treiman，1997）， 6 －year－olds show some knowledge about the allowable positions of extended consonants．When they use＜ck＞or a double consonant like＜ff〉，they are less likely to place it at the beginning of a word than in the middle or at the end． Children do this even when they haven＇t been explicitly taught that these
spelling sequences aren＇t allowed at the beginnings of words（Cassar \＆Treiman， 1997；Treiman，1993）．Children＇s knowledge about the allowable positions of doubled letters is also revealed when they are asked to judge the wordlikeness of novel items．When asked which looks more like a word of their language， a nonword with a double final consonant such as «beff» or a nonword with a double initial consonant such as «bbef»，US 6－year－olds tend to pick the former item（Cassar \＆Treiman，1997；Cassar，Treiman，Moats，Pollo，\＆Kessler，2005； Wright \＆Ehri，2007）．Additional evidence that young children are sensitive to the allowable positions of doubled consonants comes from their misspellings of newly learned items．The US 6 －year－olds in one study，after having been presented with «rrip» and taught to read it as／ııp／，sometimes misspelled it as＜ripp＞（Wright \＆Ehri，2007）．The children who made this error apparently remembered that «rrip» included a doubled consonant but forgot which letter was doubled．The children used their general knowledge about doubling－that it may occur on final consonants but not initial ones－to produce＜ripp＞．This result supports IMP＇s view that spelling errors reflect knowledge about general patterns as well as memory for the spellings of specific words．

French children，like US children，learn at an early age about certain constraints involving the position of double consonants．In French，double consonants sometimes occur in the middles of words but hardly ever at the beginnings or the ends．Correspondingly，when asked to finish partially com－ pleted spellings of novel items，French 6－year－olds were more likely to place a double consonant such as $\langle l>$ in the middle of a word than at the end（Pacton， Perruchet，Fayol，\＆Cleeremans，2001）．Knowledge of another pattern－that a doubled consonant may follow a vowel（as in messe＇mass＇）but not another con－ sonant（melsse isn＇t acceptable）—emerges a little later，around $7^{1 ⁄ 2} 2$ or 8 years of age（Alegria \＆Mousty，1996；Pacton \＆Fayol，2000）．Children may require more time to learn this latter pattern because the letters involved aren＇t at the edge of a word．Also，the latter pattern involves abstract categories of letters， consonants and vowels．

In theory，children could learn separately about the positional constraints involving each double consonant．For example，French children could learn that ＜ll＞may not occur at the beginning of a word and，as a separate piece of infor－ mation，that «rr＞may not occur at the beginning of a word．However，children appear to generalize to some extent．For example，French children have almost never seen words that include＜ji＞or 〈hh＞，as neither double consonant occurs in French．But children seem to infer that，if 〈 h$\rangle$ and $\rangle$ 〉 did double，as $\langle\mathrm{l}\rangle$ and $\langle\mathrm{r}\rangle$ do，they would do so in the middles of words，as in 〈hojjir»，rather than at the beginnings，as in 〈hhojir»．This inference is revealed in wordlikeness judgment tasks at the age of 6 （Pacton et al．，2001）．French 7 －year－olds also prefer non－ words such as «hojijir＞over those such as «hojiir» even though neither 〈ji＞or «ii＞ occurs in French．These children appear to have learned that the letters in one class，consonants，sometimes double，but that the letters in another class，vow－ els，rarely double．Similarly，US 6－year－olds tend to reject «hhenis» as a possible word（Cassar \＆Treiman，1997）．Although they haven＇t seen words containing
＜hh»，they seem to infer that «h＞，like other consonants，shouldn＇t double at the beginnings of words．Children＇s generalization isn＇t complete－French chil－ dren don＇t show as strong a dislike for «hhojir»（which has a double consonant that never occurs in French）as for dluret»（which has a double consonant that does occur in the middles of words）－but children generalize to some extent． That is，children learn patterns that apply to sets of letters．

We have seen that certain patterns that can be understood on a graphic basis are learned early and well．That finding doesn＇t support the idea that young children choose spellings＂strictly on the basis of sound，without regard for acceptable English letter sequence or other conventions of English orthography＂（Gentry，1982，p．195）．The research findings show that children learn about certain graphotactic patterns earlier than phase theory predicts， especially patterns that involve letters at the edges of words and patterns that involve repeated letters．Graphotactic patterns that require attention to the middles of words and to more abstract categories such as consonant versus vowel appear to be learned later．That is，children don＇t learn all graphotactic patterns at the same time．

## 11．4 Conditioning by Stress

So far，we have considered cases in which the distribution of spellings for a phoneme differs as a function of its position or of the surrounding segments． In other cases，the distribution of spellings for a phoneme differs accord－ ing to whether the phoneme occurs in a stressed or unstressed syllable．In Brazilian Portuguese，for example，final $/ \mathrm{u}$／is spelled as $\langle\mathrm{u}\rangle$ when stressed， as in urubu／uru＇bu／＇vulture＇．If it isn＇t stressed，as is much more typical at the ends of words，it is almost always spelled as «o»，as in sapo／＇sapu／＇frog＇． Likewise，final／i／is spelled as «i» if stressed and «e» if unstressed．The dif－ ferences in spelling as a function of stress reflect changes that occurred over time in the pronunciations of unstressed vowels．Whereas the pronunciations of these vowels changed，the spellings didn＇t．Although the spellings of final $/ \mathrm{u} /$ and $/ \mathrm{i}$／are quite predictable，the pattern takes some time for children to learn．The oldest group of children in one study，who were about 10 years old， hadn＇t yet mastered the rule（Nunes，Roazzi，\＆Buarque，2003）．One reason for this difficulty is that children＇s knowledge of letter names suggests that final unstressed／u／and／i／should be spelled with 〈u〉 and 〈i»，respectively，which is incorrect．Indeed，we mentioned in $\mathbb{1 0 . 2 . 1}$ that Brazilian 5 －year－olds often spell words like sapo＇frog＇with final $\langle\mathrm{u}\rangle$ ．Children must overcome the influ－ ence of one pattern in order to learn another．Another source of difficulty may lie in the need to consider stress．That is，children must consider not only the identity of the vowel they are attempting to spell but also whether it is stressed or unstressed．This is hard to do，in part because distinctions of stress are often erased when saying words slowly for the purposes of spelling．These things mean that a highly consistent pattern takes quite some time to learn．

### 11.5 Conditioning by Morphology

The basic units of some past and present writing systems, including Chinese, symbolize morphemes. However, a number of writing systems that are fundamentally alphabetic also take morphology into account. In such writing systems, as we discussed in $\int_{2.2 .2 .5}$, a morpheme may be spelled alike in different words, even when its pronunciation differs. A writing system of this sort is said to show a degree of morphemic constancy. In writing systems of these kinds, a speller can't proceed phonologically without paying attention to morphology. A speller of English must consider, for example, whether the /tæks/ he wishes to spell is morphologically simple, in which case he should write <tax>, or whether it is morphologically complex, in which case he should write stacks>. In this section, we ask whether the need to do this taxes the speller.

### 11.5.1 Influences of Morphology on Spelling

In writing systems that show a degree of morphemic consistency, do children consider morphology when deciding on spellings? In some cases, even young children appear to do so. For English, one such case involves morphemes that end with a stressed vowel followed by /t/ or /d/. When an unstressed inflectional or derivational suffix that begins with a vowel is added to such a morpheme, speakers of American English generally pronounce the $/ \mathrm{t} / \mathrm{or} / \mathrm{d} /$ as a quick tap of the tongue just behind the upper teeth: [r]. The tap is voiced, meaning that the vocal cords vibrate during its production. Tapping occurs, for example, in the inflected words waited and louder. As discussed in $\int 10.4 .4$, children often spell taps as $\langle\mathrm{d}\rangle$, in line with their voicing. Based on sound alone, one would expect children to be equally likely to use a <d» to spell the tap of the morphologically complex word waited and the tap of the morphologically simple word duty. However, children could choose st> for waited if they know that it contains a stem with a final /t/ that is spelled as «t> and if they tend to spell that stem consistently. That is, the rate of $\langle\mathrm{t}\rangle$ spellings should be higher for two-morpheme words such as waited than for one-morpheme words such as duty if children take morphology into account. Such a difference has been found in US children as young as 6 years old, both when spelling words to dictation and when choosing between «d» or «t> to complete a spelling (Bourassa, Treiman, \& Kessler, 2006; Treiman, Cassar, \& Zukowski, 1994; Wolter, Wood, \& D'zatko, 2009). According to the research, the easiest taps for children to spell correctly are those in words like louder. In this case, phonology suggests the correct <d> spelling and analysis of the word into morphemes supports this analysis. The most difficult taps for children to spell correctly are those in words like duty. In this case, phonological considerations suggest the wrong spelling of the flap, <d>, and no morphological analysis speaks against this. Intermediate in difficulty are taps such as those in meadow, where the correct spelling is motivated by phonology but not by morphology, and taps
such as those in waited, where the correct spelling is motivated by morphology but not phonology. The results support IMP's idea that multiple patterns influence spelling. Children tend to spell taps well when two patterns converge on the same answer and poorly when this isn't the case. Although the children in the studies we have been describing were influenced by morphology to some extent, they were less likely to use «t> in a two-morpheme word like waited than in a one-morpheme stem like wait. Still, it is notable that children who hadn't been explicitly taught about the role of morphology in spelling used it to some extent (Wolter et al., 2009). Another notable finding is that, when derivation involves transparent and common suffixes such as agentive -er (e.g., cheater) and adjective-forming $-\gamma$ (e.g., dirty), children spell the taps of derived words as well as the taps of inflected words (Treiman, Cassar et al., 1994). These results speak against the idea that children learn about the role of derivational morphology in spelling only after they learn about the role of inflectional morphology (Henderson \& Templeton, 1986). Rather, the findings suggest, some derivations are as easy as some inflections.

Further evidence that even young spellers of English sometimes consider words' morphological structure comes from studies involving final consonant clusters. As we saw in chapter 10, children sometimes fail to spell the first consonants of such clusters. However, consonants like the /n/ of tuned /tund/ and the $/ \mathrm{s} /$ of missed /mist/ should be protected from spelling omissions if children tend to retain the spellings of stems when they spell inflected words that contain those stems. In several studies (Bourassa et al., 2006; Rubin, 1988; Treiman \& Cassar, 1996; but see Larkin \& Snowling, 2008), children as young as 5-6 years of age omitted the $/ \mathrm{n} /$ of a word like tuned less often than the $/ \mathrm{n} /$ of a word like brand /brænd/. Similarly, children omitted the /s/ of a word like missed less often than the /s/ of a word like feast /fist/. The children didn't always retain the spellings of the stem, but they did so to some extent.

Further evidence that English speakers as young as 6 years of age sometimes consider morphology in spelling comes from comparisons of performance on one-morpheme words like rocket/'sakıt/ and two-morpheme words like rocked /akkt/. The words are similar in frequency and length, and on those grounds we would expect the words to be similar in spelling difficulty. However, the 6 -year-olds in one study spelled words like rocked more accurately than words like rocket (Deacon \& Bryant, 2006). That is, children's experience with the stem rock seemed to carry over to rocked.

In Hebrew, as in English, morphological considerations can sometimes help in choosing among alternative spellings for phonemes. For example, /t/ is sometimes spelled ט and sometimes ת. The two letters originally represented different consonants. The distinction between the phonemes was lost for most speakers, but the spellings weren't updated to reflect that change. The phoneme $/ \mathrm{t} / \mathrm{is}$ always spelled $\Omega$ when it is part of an affix. Knowledge of this pattern could help a speller to select the correct letter for the $/ \mathrm{t}$ / of a word such as תפיל/ta'pil/, an imperative form of 'drop’, where /ta/ is a prefix. From the age of 6 , Israeli children perform quite well on the $/ t$ / of words like this, better
than on the /t/ of words like תקין /ta'kin/ 'in working order', where /ta/ isn't a prefix (Gillis \& Ravid, 2006).

Several factors help to explain why even young spellers take account of words' morphological structure in the cases we have discussed. In these cases, it is fairly easy for children to conceptualize the words as containing more than one morpheme. The spelling predicted by morphology isn't unexpected from a phonological or graphic point of view, and the link between this spelling and the morpheme is strong. When these conditions don't hold, it may take a number of years for children to begin to use morphology in their spelling. Consider the French sequence $/ \varepsilon t /$, which may be spelled in a number of ways, including «aite», «ette, <ête, and «ète. The choice is influenced by the morphological status of / $\mathrm{\varepsilon t} /$ : The spelling is always «ette> when $/ \mathrm{st} /$ is a diminutive suffix, as in filette 'young girl' and vachette 'young cow'. But some words that aren't diminutives, including gazette 'newspaper', also use «ette). Similarly, /o/ is virtually always spelled as «eau» when /o/ is a diminutive. When /o/ isn't a diminutive, it may be spelled as «eau> or in other ways. The link between the special spelling-<ette» or «eau-and diminutive status is weaker in the case of «eau» than the case of eette. That is, the proportion of words that aren't diminutives that have the «eau» spelling of /o/ is larger than the proportion of words that aren't diminutives that have the eette> spelling of $/ \mathrm{\varepsilon t} /$. Correspondingly, children begin to produce more special spellings when a nonword is marked as a diminutive (for example when a /sobivet/ is said to be a little /soriv/) than when it isn't marked as a diminutive about a year earlier in the case of / $\mathrm{ct} /$ than in the case of /o/ (Pacton, Fayol, \& Perruchet, 2005).

Children find it difficult to learn a special spelling of a morpheme when that spelling deviates from the one expected on the basis of other phonological or graphic patterns. This is often the case with the English past tense morpheme, helping to explain why children learn its spelling relatively slowly. The US 6 -year-olds in one study produced more «ed spellings of $/ \mathrm{t} /$ and $/ \mathrm{d} /$ when these were regular past tense endings, as in messed /mest/, than when they weren't regular past tense endings, as in fast /fæst/ (Treiman, 1993). However, «t> spellings of regular past tense / t / and $<\mathrm{d}$ » spellings of regular past tense /d/ outnumbered correct eed» spellings among the 6 -year-olds in this and some other studies (Larkin \& Snowling, 2008; Varnhagen, McCallum, \& Burstow, 1997). Indeed, some children make errors such as «calld» for called /kold/ even after several years of literacy instruction that includes explicit instruction about the use of «ed» (Larkin \& Snowling, 2008; Nunes, Bryant, \& Bindman, 1997; Varnhagen et al., 1997). The oddity of spelling /t/ and /d/ with «ed» helps to explain why learning proceeds slowly in this case. A single consonant phoneme is more often spelled with a single letter than with a digraph. When a two-letter sequence is used to spell a single consonant sound, both letters are normally consonants. These things make the ed> spelling for /t/ and /d/ quite odd. The «ed» spelling of the past tense marker is less odd when the past tense is /əd/, as hunted, than when it is /d/ or /t/. Correspondingly, children
appear to produce more correct spellings of past tense /əd/ than of past tense /d/ or /t/ (Treiman, 1993; Varnhagen et al., 1997).

The difficulties that French-speaking children have in spelling certain inflectional endings also reflect, in part, the unexpectedness of their conventional spellings. For example, /t $\tilde{\varepsilon} \mathrm{b} b /$ 'stamp' is spelled <timbre> when it is a singular noun, <timbres> when it is a plural noun and also when it is a second person singular present tense verb, but it is spelled as <timbrent> when it is a third person plural present tense verb. The words are pronounced alike in isolation and often also in connected speech, although the silent endings are occasionally pronounced in connected speech when the next word begins with a vowel. The endings were always pronounced earlier in the history of the French language; they have been dropped in most spoken contexts and retained in spelling. Expecting the letters <s $\rangle$ and <nt $\rangle$ to represent pronounced phonemes, French children often fail to include them when they are silent grammatical endings. For example, 6- and 7 -year-olds often write amis 'friends' as <ami> even though almost all French nouns have <s> as their plural marker (Fayol, Totereau, \& Barrouillet, 2006).

French children are less likely to mistakenly add a final <s $\rangle$ to the singular than to mistakenly omit it from the plural (Largy, 2001; Largy, Cousin, Bryant, \& Fayol, 2007). The substitution of 〈ami> for <amis» is motivated not only by the fact that the word ends with a vowel sound but also by the fact that the graphic sequence «ami» is more common than «amis»-for most words, singulars are more common than plurals. In those atypical cases in which children have had more exposure to the written form of the plural than of the singular, as with parents 'parents', substitution of the singular for the plural (i.e., <parent> for <parents») still outnumbers substitution of the plural for the singular (i.e., <parents» for <parent»), but by a smaller margin (Cousin, Largy, \& Fayol, 2002; Largy et al., 2007). In adults, too, a spelling mistake such as <il les asperges> for il les asperge 'he splashes them' is more common when it yields a word that writers have seen and stored in memory, in this case asperges 'asparagus', than when it yields a nonword or an uncommon word (Largy, Fayol, \& Lemaire, 1996). Writing <asperges» in error is especially common if the speller has been induced to think about gardeners and vegetables. These results support IMP's idea that multiple patterns influence spellings: in this case, stored memories for specific spellings and also knowledge of general patterns pertaining to morphology.

We have discussed several reasons why users of alphabetic writing systems sometimes fail to use morphological conditioning. One reason that we haven't yet discussed is that, in these writing systems, morphemes aren't always spelled in a consistent manner across the different words in which they appear. For example, «explanation» doesn't retain the «ai» of «explain». In some cases, rules govern when morphology is retained in spelling and when it isn't. For example, English-speaking children appear to learn by the age of 8 or 9 that verbs that change their vowel from the present to the past tense spell the past tense ending as «d» or «t> (<kept>/kept/, present/kip/ keep; 〈held> /held/, present /hold/
hold), whereas regular verbs used «ed». Children learn this even when the rule isn't explicitly taught at school (Bryant, Nunes, \& Snaith, 2000). Still, the fact that some common past tense forms end with «d» and «t> as opposed to «ed» probably contributes to children's slow learning of the regular «ed» ending. In other cases, it is difficult to predict when the spelling of a morpheme will be retained and when it won't. Children make some errors in this process. For example, French 9 -year-olds sometimes misspell choix / Jwa / 'choice' with a final $\langle\mathrm{s}\rangle$, reflecting the influence of choisir 'choose' (Sénéchal, Basque, \& Leclaire, 2006). Eight- to 12 -year-old learners of English sometimes write <explaination> for explanation and «hungery» for hungry (Bourassa \& Treiman, 2008). And Danes sometimes misspell jysk /jysk/ ‘Jutlandish’ as «jydsk> (Juul \& Elbro, 2004). This adjective is derived from jyde /'jy:ðə/ ‘Jutlander', but the «d» of <jyde> doesn't appear in the conventional spelling of the derived adjective, as is normally the case in Danish.

Linguistic knowledge is an important foundation for spelling, according to IMP, and spelling errors may reflect a difficulty in analyzing language in the way that is required for spelling. Errors that arise for this reason are common in the case of morphologically complex words. For English, they are especially common for words that derive from Greek and Latin: complex words that tend to be learned relatively late. For example, a 12 -year-old speaker of English might not know that vacation has vacate as a stem, even if he knows the word vacate. Thus, he may spell vacation with <sh〉 rather than «t> (Sterling, 1983). Similarly, an adult who knows the meaning of euphonious may not know that it contains a prefix meaning 'good' that is normally spelled as <eu» and a stem meaning 'sound' that is normally spelled as <phon». Lacking this linguistic knowledge, the adult may spell the word <ufonious».

Not only do people sometimes fail to analyze morphologically complex words, but they also sometimes analyze simple words as containing more than one morpheme or analyze complex words or phrases in unintended ways. This can lead to the misspellings that have been called eggcorns, after the spelling that was produced when someone analyzed acorn as a compound of egg and corn. Someone else wrote about being in «excellerated» classes in school, evidently thinking that accelerated classes are for those who excel (Wilde, 1992). Spellings that begin as eggcorns sometimes become accepted in a language. For example, the first $\langle\mathfrak{u}\rangle$ of minuscule is motivated by the $\langle\mathfrak{u}\rangle$ of minus, but people sometimes spell the word as «miniscule», thinking that it has the prefix mini-. This has become so common than most dictionaries now list «miniscule» as a variant spelling.

To arrive at the correct morphological analysis of a word, one must sometimes consider not just the word itself but also its function within a phrase or sentence. In the French Le chien des voisins arrive 'the dog of the neighbors arrives', for example, it is le chien 'the dog' that determines that the verb should be the singular arrive rather than the plural arrivent; the pronunciation of both forms is the same, /авіv/. French children sometimes produce errors such as <Le chien des voisins arrivent», making the verb agree with the adjacent plural noun voisins 'neighbors' rather than with its nonadjacent subject (Van Reybroeck \& Hupet, 2009). Even university students make occasional errors of
this sort under some conditions（Fayol，Largy，\＆Lemaire，1994）．These results show that conditioning factors are difficult to use when they are some distance from the target，an idea that is further supported by studies with Dutch spellers （Assink，1985；Bosman，2005；Sandra，Frisson，\＆Daems，1999）．With morpho－ logical conditioning，as with other types of conditioning，people probably find it easier to use nearby conditioners than more distant ones because the nearby ones are more likely to be in the same focus of attention as the target．People＇s cognitive abilities and limitations，here the limited nature of attention，influ－ ence their spelling．

Supporting the role of attention in the spelling process，failures to consider morphology are more common when people aren＇t paying full attention to the task of spelling than when they are．Thus，distraction causes experienced writ－ ers of French to make errors on grammatical homophones that they wouldn＇t normally make（Fayol et al．，1994；Largy et al．，1996）．French children are less likely to use silent agreement markers when they write an entire word or sen－ tence than when they fill in a partially completed spelling of a word（Fayol et al．，2006；Van Reybroeck \＆Hupet，2011），showing that they devote more attention to spelling the ending when other demands on them are reduced．

Studies of morphological conditioning support IMP＇s claim that children use patterns of different types to help learn and remember spellings．In par－ ticular，spellings that are well motivated both morphologically and in other ways tend to be easier to learn than spellings that follow a single pattern．We saw evidence for joint use of morphological and phonological motivations with words like louder pronounced［＇laurə＇］（ $\$ 11.5 .1$ ）．The $\langle\mathrm{d}\rangle$ is phonologically moti－ vated for a child by the voicing of the tap and morphologically motivated by the fact that the stem ends with／d／．Consequently，children perform better on the taps of words like louder than on the taps of other words．As another example of the use of multiple patterns，the＜s＞of fibs／fibz／is motivated by the fact that regular plurals in English always end with «s» and by the fact that the choice of 〈Z〉 would lead to a graphically unusual result，«fibz〉．In fees／fiz／，«s＞ is motivated morphologically but less so graphotactically：the alternative spell－ ing 〈feeze» is graphotactically acceptable．Correspondingly，children are more likely to use a final 〈s〉 when spelling plurals like fibs than those like fees（Kemp \＆Bryant，2003）．Yet another piece of evidence for the use of multiple patterns comes from the finding that French children and adults are more likely to use the «ette» ending when／soвivet／appears in a diminutive context than when ／sobitst／appears in a diminutive context（Pacton et al．，2005）．There are two reasons to use «ette» in the former case：«ette» is often used for diminutives and ＜vette» is a fairly common sequence．There is less reason to use＜ette» in the latter case：«tette» isn＇t a common sequence in French words．

## 11．5．2 Summary of Results on Morphological Conditioning

Learners of alphabetic writing systems that take morphology into account use morphological considerations，real or invented，to help motivate letters in
spellings．They do this from early childhood under favorable circumstances， later or never under less favorable circumstances．Phase theory suggests that the ability to use morphological conditioning emerges relatively late，during the consolidated alphabetic stage．The research we have reviewed，however， shows that there is no simple answer to the question of whether morphologi－ cal conditioning emerges early or late．The degree to which spellers use a par－ ticular morphological pattern depends on the degree of statistical support for the pattern，the degree to which the spellings that it suggests mesh with those suggested by other patterns，the speller＇s linguistic knowledge，and the spell－ er＇s attention to conditioning factors．Not all patterns involving inflectional morphology are equally easy in these respects，and not all patterns involving derivational morphology are equally difficult．

## 11．6 Other Types of Conditioning

So far in this chapter we have discussed a number of conditioning factors that may influence children＇s choice among alternative phonograms：surrounding segments，stress，and morphology．In this section，we consider several other sorts of conditioning factors．The brevity of the section reflects not the lack of importance of these patterns but the lack of research on them．

In some cases，the grammatical category of a word influences in spelling． Consider Italian，in which／k／may be spelled as either «c＞or 〈q＞before／w／， as in cuore＇heart＇and questo＇this＇．The $\langle q\rangle$ spelling is more common in func－ tion words，whereas the 〈c＞spelling is more common in content words such as nouns and verbs．There is some evidence that Italian adults have an implicit knowledge of this pattern（Barry \＆de Bastiani，1997）．

In a number of languages，borrowed words tend to retain the spellings that they had in the original language．For English，this conservatism has led to the state of affairs described by Albrow（1972）and Carney（1994）and summa－ rized in $\mathbb{\int 2 . 9}$ ，where spelling correspondences often depend on which part of the vocabulary a word belongs to．For example，／f／is spelled as «ph in words in the Greek system of the English vocabulary（e．g．，philosophy）and as＜f＞or〈ff〉 in other words．Businesspeople and advertisers assume that people are sensitive to these differences．For example，the spelling «Häagen－Dazs» for a brand of ice cream was chosen to evoke old－world craftsmanship and tradition． The spelling suggests that the ice cream perhaps comes from a Scandinavian country，an impression that is strengthened by the map of Denmark on the ice cream containers．However，the company was started in New York，as several people of our acquaintance were dismayed to learn．As another example，the names of pharmaceuticals are sometimes spelled with $\langle\mathrm{ph}\rangle$ or $\langle\mathrm{x}\rangle$ to suggest that they belong to the Greek or Latinate portion of the vocabulary：learned， scientific，and complex．Researchers may have tested whether a drug named Phizolex sells better than a drug named Fisolecks，but the results are classified information．

One unclassified study did touch on the role of vocabulary stratum in adults＇ use of extended consonants in two－syllable English words．In words with cer－ tain Latinate endings such as－ic，including «tonic»，medial consonants don＇t normally double after short vowels as they would in native words like＜sunny＞． Correspondingly，university students were less likely to double a medial con－ sonant when spelling nonwords with the former endings than those with the latter（Binte Faizal \＆Treiman，2012）．

## 11．7 Unconditioned Inconsistencies

In some cases，as we have seen，context can help in choosing the correct spelling for a phoneme．In other cases，a phoneme has two or more possi－ ble spellings in the same context．Spellers usually have more difficulty with these unconditioned inconsistent spellings，in which appeals to context don＇t help，than with conditioned spellings．Even Spanish and Italian，which are often considered very simple writing systems，have some unconditioned inconsistencies．For example，Spanish／j／is sometimes spelled＜ll＞，as in pollo ＇chicken＇，and sometimes 〈y＞，as in poyo＇windowsill＇．No conditioning factor can tell which spelling is used in which case．Ten－year－old Spaniards some－ times misspell everyday words such as pollo and poyo，even while performing well on other sorts of words（Defior，Jiménez Fernández，\＆Serrano，2006； Defior，Jiménez－Fernández，\＆Serrano，2009），and similar findings have been reported for Italian children（Notarnicola，Angelelli，Judica，\＆Zoccolotti，2012）．

Unconditioned inconsistencies often arise in the course of sound change． One phoneme，regardless of phonetic context，changes to merge with another phoneme that already existed in the language．If the spellings aren＇t updated， the phoneme that results from the merger now has two different spellings． In the Spanish example，words like pollo and poyo used to have different pro－ nunciations：／＇poко／and／＇pojo／，respectively．Then $/ K /$ changed to $/ \mathrm{j} /$ in all words，but the spellings didn＇t change．Consequently，modern $/ \mathrm{j} /$ is now spelled two different ways in different words．To get a better idea of how chil－ dren deal with unconditioned inconsistencies，we turn now to studies that have examined specific cases．

We have already mentioned the case of taps of American English（ $\$ 10.4 \cdot 4$ ， $\int 11.5 .1$ ）．Although／t／and／d／are usually pronounced differently and spelled differently，they have merged into one sound in certain environments．The result is a voiced segment，a tap［ r$]$ ，that is sometimes spelled with $\langle\mathrm{t}\rangle$ or $\langle t \mathrm{t}\rangle$ and sometimes spelled with 〈d» or 〈dd»．Morphological considerations sometimes help in spelling the tap，as discussed earlier．However，morphology doesn＇t help for many words，including water and nobody．US children are more likely to misspell＜t＞and «d＞when these correspond to taps，as in water and nobody， than when they don＇t，as in pretend and under（Treiman，1993；Treiman，Cassar， et al．，1994）．Indeed，even US university students occasionally misspell taps in uncommon words，writing 〈loider» for loiter or «pagotta〉 for pagoda（Treiman
\& Barry, 2000). Such errors are rare among British university students, who don't show tapping in their speech. For Americans, though, choosing between <t> and <d> in words like loiter, pagoda, and body involves some rote memorization on a word-by-word basis.

Phonologically, <d> spellings of taps are better motivated than <t> spellings because taps are voiced. However, «t> spellings of taps are more common in English than <d> spellings. This is increasingly true in the words that appear in reading materials for older students (Bourassa et al., 2006). This increase probably reflects the fact that many words of Latin origin, which are increasingly common for older students, contain taps spelled as <t> (e.g., sanity, fetid). When students of different ages spell the same set of words containing taps, therefore, older students increasingly favor «t> (Bourassa et al., 2006; Treiman, Cassar, et al., 1994). For example, the 6- and 7 -year-olds in one study performed better on taps that were conventionally spelled as <d> than on taps that were conventionally spelled as <t> (Treiman, Cassar, et al., 1994). Nine- and 10-year-olds made fewer errors overall, but the errors that they did make were more often on taps that were conventionally spelled as $<\mathrm{d}\rangle$ than on taps that were conventionally spelled as 〈t>. These older students had probably learned that the choice of <t> is more likely to lead to a correct spelling. The findings suggest that spellers supplement their knowledge about the spellings of taps in specific words with knowledge about the phonological properties of taps and about the relative probabilities of the «t> and «d» alternatives in the language. Phonological knowledge-taps are more similar to /d/ than to /t/-is especially important for younger children, boosting their performance on words like meadow. Knowledge about the graphic probabilities of the alternatives-<t> is a more common spelling than $\langle\mathrm{d}\rangle$-is increasingly important for older students, boosting their performance on words like duty. These results are consistent with IMP's claim that spelling is influenced both by knowledge that is specific to a particular word and knowledge that is more general.

Another type of merger occurs when voiced consonants at ends of words become voiceless, merging with voiceless consonants that were already in the language. The process, devoicing of final consonants, occurs in a number of languages and dialects, one of which is the dialect of English that is spoken by many African Americans. Adult speakers of this dialect sometimes produce misspellings such as <haggart» for haggard and «ballad» for ballot. Spelling errors of this kind are less common in those who don't devoice final consonants (Treiman, 2004). Children who speak African American English have also been reported to make spelling errors that reflect final consonant devoicing (Kohler et al., 2007).

Long consonants sometimes merge with their short counterparts as a result of sound change, as mentioned earlier in this chapter ( $\$ 11.2 .6$ ). If the long consonants were originally spelled with double letters, and if the spellings don't change, this means that «bb» and «b», for example, stand for the same phoneme after the sound change has occurred. In many Germanic languages, consonant doubling was originally correlated with vowel length. The choice
between single and double consonant spellings now depends in part on the nature of the preceding vowel，as discussed earlier．In French，where conso－ nant doubling wasn＇t usually correlated with vowel length，the choice between single and double consonant phonograms doesn＇t usually depend on the pre－ ceding vowel．Morphology sometimes helps，but in other cases spellers need word－specific knowledge to be sure whether a consonant that occurs between two vowels should be spelled with a single consonant，as in formule＇formula＇， or a double consonant，as in bulle＇bubble＇．In choosing between single and double consonants，French children as young as 6 years of age take advantage of the fact that single consonants are more common than double ones（Pacton \＆Fayol，2000；Pacton et al．，2001）．Children also take advantage of the fact that some consonants，including «t＞and «l＞，are more likely to double than others． French children＇s knowledge of these patterns begins to emerge at 6－7 years of age（Pacton et al．，2001）．Although knowledge of graphotactic patterns helps people to learn and remember the correct spellings of many consonants，this knowledge can cause them to make errors on words with atypical spellings． For example，after having read a story containing a novel word，French univer－ sity students have more difficulty remembering the spelling if it contains an uncommon double letter，as in «baggotin»（＜g＞rarely doubles in French），than if it contains a common double letter，as in «bagottin»（＜t＞often doubles）．They sometimes misremember «baggotin» as «bagottin»，doubling the «t＞rather than the 〈g＞（Pacton，Borchardt，Treiman，Lété，\＆Fayol，2013）．Mergers leading to unconditioned inconsistencies have occurred in other languages as well．In Hebrew，as mentioned in §11．5．1，ט used to be $/ \mathrm{t}^{\mathrm{\Sigma}} /$ and $\Omega$ used to be $/ \mathrm{t} /$ ．For most speakers of Hebrew they are both now pronounced as $/ \mathrm{t} /$ ．The fact that $/ \mathrm{t} /$ is sometimes spelled with $ט$ and sometimes spelled with $ת$ causes difficulties for children（Gillis \＆Ravid，2006）．As another example，Spanish has a pho－ neme that is sometimes spelled «b〉 and sometimes 〈v＞，as in base／＇base／＇base＇ and vaso／＇baso／＇glass＇（2．8）．Children must learn the correct spellings on a word－by－word basis，and they make mistakes in this process（Justicia，Defior， Pelegrina，\＆Martos，1999）．

In many of the cases we have discussed，the pronunciation change that led to a merger may be described as weakening：A segment is articulated in a weaker or more neutral way in some or all of the contexts in which it occurs． In the cases we have been discussing，the segment comes to be pronounced the same as another segment that already exists in the language．The ultimate weakening of a sound is its complete loss．One example，which was mentioned earlier，involves the loss of consonants at the end of French words．This has happened in the word effort／efэь／＇effort＇，which is now spelled with a final ＜t＞that isn＇t pronounced．The final letter in trésor for／tвеzэь／＇treasure＇，in contrast，corresponds to a pronounced consonant．Correspondingly，French children are more likely to misspell words like effort than words like trésor，even when the words are similar in other ways（Sénéchal et al．，2006）．

Consonants that are already weak，such as／h／，are especially susceptible to loss．The loss of initial $/ \mathrm{h} /$ has led in some languages to a situation in which
some words that begin with a vowel phoneme have a spelling that begins with〈h〉 and others don＇t．For example，Spanish hora／＇ora／＇time＇is spelled with an initial «h» but agua／＇agwa／＇water＇isn＇t．Spanish has many more words of the latter type than the former type，though（Cuetos，1993）．Learners of Spanish often omit «h» when spelling words like hora（Defior et al．，2006；Defior et al．，2009； Justicia et al．，1999）．By 8 to 10 years of age，children make some spelling errors such as «hagua» for agua，adding an initial «h＞where it doesn＇t belong．However， additions are less common than omissions（Justicia et al．，1999）．Omissions of «h» have also been noted among learners of Kannaḍa，who drop／h／in their speech（Nag，Treiman，\＆Snowling，2010）．Kannaḍa is unrelated to Spanish，but the omissions reflect a type of sound change that occurs in a number of lan－ guages，together with the fact that speech changes more quickly than writing．

Another weak consonant that is susceptible to loss is $/ \mathrm{J} /$ ．British English and Australian English，among other dialects of English，are said to be non－ rhotic in that $/ \mathrm{J} /$ is dropped in syllable codas．For example，«corn» and «car» are pronounced without $/ \mathrm{I} /$ ．Reflecting the conservatism of written language，the spellings haven＇t changed to reflect this．One consequence is that «or» is now a fairly common spelling of $/ \mathrm{J} /$ for speakers of nonrhotic dialects．For example， corn contains a／／／that is spelled as＜or＞．Other words have／ $\mathrm{J} /$ spelled with ＜au» or «aw»，including dawn and caucus．The diversity of spelling alternatives for $/ \mathrm{J} /$ ，together with the lack of conditioning factors，means that children who speak a nonrhotic dialect of English sometimes produce misspellings such as «dorn» for dawn and＜con» for corn（Treiman，Goswami，Tincoff，\＆Leevers， 1997）．University students who speak a nonrhotic dialect make similar errors on less common words，including «corcus» for caucus and «torny＞for tawny （Treiman \＆Barry，2000）．

The loss of $/ \mathrm{x} /$ in nonrhotic accents also means that both «ar» and «a＞are common spellings of $/ \mathrm{a} /$ ，as in card and father．The existence of several alterna－ tive phonograms and the lack of conditioning factors contributes to children＇s errors such as «cad» for card and «barth» for bath／baӨ／（Treiman，Goswami， et al．，1997）．Adult speakers of nonrhotic dialects make similar mistakes on less common words，sometimes writing «gnal» for gnarl／nal／and «kharki» for khaki／＇kaki／（Treiman \＆Barry，2000）．Speakers of rhotic dialects，who include／ $\mathrm{I} /$ in their speech，are less likely to make such errors．

Nonrhotic dialects also changed $/ \partial /$ to $/ \partial /$ ．Thus $/ \partial /$ in these dialects is now often spelled with a vowel letter followed by 〈r＞，as in tiger，pronounced ／＇targə／in such dialects．In these dialects，vowel－«r＞spellings of／ə／are more common than single vowel spellings of $/ \partial /$ at the ends of words．That is，words like tiger outnumber words like comma．Children sometimes choose the wrong phonogram for final $/ ə /$ ，with 7 －year－old speakers of non－rhotic accents some－ times writing «docda＞for doctor／＇dpktə／or «kuve» for cover／＇kлvə／（Treiman， Goswami，et al．，1997）．Errors like＜piser＞for pizza／＇pitsə／，which use the vowel－«r» phonogram，appear to increase with spelling experience．This result suggests that children need a fair amount of experience with conventional spell－ ings like＜tiger＞to break away from the idea that／ə／should be spelled with a
single vowel letter and to learn that, at the end of a word, it is often spelled with the graphically more complex and phonologically less expected vowel-<r> phonogram. British university students with nonrhotic accents sometimes misspell final /ə/ in relatively uncommon words, making errors such as 〈lepa> for leper /'lepə/ and «polker» for polka /'pplkə/ (Treiman \& Barry, 2000).

The choice among spelling options is influenced by the graphic and phonological plausibility of the options, as we have seen. It is also influenced by recent use of one of the options. Thus, the Spanish adults in one study were more likely to choose $\langle\mathrm{v}\rangle$ to spell the /b/ of a nonword immediately after they had used <v> to spell the /b/ of verga /'berga/ 'gate' than after they had spelled a word that began with /b/ spelled as «b> or a word that didn’t contain /b/ (Cuetos, 1993; see Barry \& de Bastiani, 1997, for similar results in Italian). This sensitivity to recent experience suggests that spelling doesn't reach a stable, unchanging state.

The results we have reviewed in this section show that unconditioned inconsistencies take time to learn. A certain amount of rote memorization is required in these cases, since children can't be sure which spelling is correct in a particular word unless they have had experience with that word. However, consistent with IMP, spelling involves much more than rote memory. Children use general knowledge that they have obtained from experience with a body of words, including knowledge about the probabilities of different spellings. They are also influenced by the graphic complexity and phonological plausibility of the phonograms and by the graphic plausibility of the result. The use of multiple sources of information helps to explain why, as mentioned in $\int 11.1$, the relative frequency of the spelling alternatives for a phoneme is an imperfect predictor of spelling difficulty. Spellers who use a simple and plausible spelling that they have used in the recent past and that yields a familiar-looking result will often be correct, even if they have had little or no experience with a word. When these things don't lead to the correct choice, as sometimes happens, even experienced spellers may misspell unconditioned segments.

### 11.8 Other Complexities

### 11.8.1 Homographs

In previous sections, we discussed one way in which alphabetic writing systems may deviate from simple one-to-one correspondences between phonemes and phonograms: A phoneme may have more than one possible spelling. We turn now to another type of deviation: Different phonemes may be spelled alike. In English, for example, $/ \theta /$ and $/ \delta /$ are both spelled «th . According to most studies, such homography at the phoneme level doesn't hurt spellers to a measurable degree (Lété et al., 2008; Spencer, 2007; Treiman, 1993; Weekes et al., 2006; but see Davies \& Weekes, 2005). Homography may also occur at the level of words. For example, English spells both /wund/ and /waund/ as
＜wound»．Children＇s responses to whole－word homography have been investi－ gated by examining their reactions when they produce homographic spellings such as «sa＞for both stay and say or «bet＞for both bet and bent．In one study，US 6 －year－olds changed their spellings about half the time when an adult pointed out that they had spelled two different－sounding words alike（Treiman，1991； see also Read，1975）．The other half of the time，the children insisted that their original spellings were correct，sometimes expressing great confidence that both stay and say should be spelled as «say＞even though the words sound dif－ ferent．In these cases，children appear to show a belief that writing need not represent all distinctions of sound．Indeed，as we saw in $\mathbb{\S} .5$ ，a number of writ－ ing systems have come to the same conclusion．They fail to represent certain distinctions，showing underrepresentation．Homography，to the extent that it occurs in writing systems，isn＇t a major stumbling block for learners．

## 11．8．2 Words With More Letters Than Phonemes

Another type of complexity is found in English words like ship／ Ip ／and home／hom／and French words like chérie／Кевi／＇dear＇and château／Jato／ ＇castle＇．These words have more letters than phonemes，and they are often ana－ lyzed as containing sequences of more than one letter that represent a single phoneme．These sequences include digraphs（«ch»，«sh»，«ie»），split digraphs （＜o〉 followed by final 〈e〉），and trigraphs（＜eau〉）．A number of researchers，espe－ cially those influenced by dual－route theories，have used the term grapheme for such sequences．Because a grapheme is defined as the smallest unit of writing， the implication is that children must memorize a spelling such as «sh＞for $/ \mathrm{S} /$ because the composition of the digraph isn＇t motivated by any patterns．

Some of the findings we have reviewed suggest that children have diffi－ culty when a single phoneme appears to be spelled with more than one let－ ter．For example，we have suggested that the time that it takes for children to learn the «ed» of «jumped»，the «er» of «tiger»，and the «o» plus final «e» of «home» may reflect，in part，the graphic complexity of the phonograms．Other studies show that spellers of English are poorer at correspondences such as that between $/ \mathrm{S} /$ and «sh＞than at correspondences such as that between ／s／and «s»，even after other factors are taken into account（Caravolas et al．， 2005；Spencer，2007；Treiman，1993）．Similar results have been reported for 6 －year－olds in Portugal（Fernandes，Ventura，Querido，\＆Morais，2008）and France（Sprenger－Charolles et al．，1998）．

Most studies of children＇s errors in the production of digraphs have exam－ ined English．In this language，one letter in a conventional digraph spelling sometimes has a strong association with the phoneme，either because the let－ ter by itself is a common spelling of the phoneme，because the letter＇s name is the phoneme or contains the phoneme，or for both reasons．The other let－ ter of the digraph isn＇t motivated in this way．In such cases，children some－ times use only the better－motivated letter of the digraph．For example，the fact that «a＞has the name／e／and is also a common spelling of／e／can cause
children to include the «a＞but omit the «e＞in words like drape／dxep／．Indeed， as mentioned in $\mathbb{1 1 0 . 2}^{10.1}$ ，US children sometimes produce errors such as＜drap＞ for drape even after several years of formal literacy instruction that includes explicit teaching about the final－＜e» pattern．Final－«e» omissions constitute a smaller percentage of children＇s vowel errors on words like some／səm／than on words like drape because the vowel letter in «some» isn＇t motivated by a let－ ter name（Treiman，1993）．Similar phenomena occur in the case of consonant digraphs．In knit／nit／，the second letter of the＜kn＞digraph is motivated by the fact that $\langle\mathrm{n}\rangle$ is a common spelling of $/ \mathrm{n} /$ and that its name includes $/ \mathrm{n} /$ ； the first letter of the digraph isn＇t motivated in either way．In ghost／gost／，the first letter of the «gh〉 digraph is motivated by the fact that it is a common spell－ ing of $/ \mathrm{g} /$ ；the second letter isn＇t motivated in such a way．Correspondingly， children are more likely to omit the first letter of 〈kn» and the second letter of «gh〉（Treiman，1993）．

With other English digraphs，neither letter alone is a conventional spelling of the phoneme and neither letter＇s name includes the phoneme．One such spelling is $\langle$ th $\rangle$ for $/ \theta /$ ．Here，as in the large majority of English consonant digraphs of this type，the second letter of the digraph is $\langle\mathrm{h}\rangle$ ．Children are more likely to include the first consonant of the digraph and omit the $\langle\mathrm{h}\rangle$ than to do the reverse（Treiman，1993）．The first letter of a sequence may，in general，be more memorable than the second．The fact that the second letter is the same across digraphs such as «th〉，«sh〉，and «ph may also contribute to omissions of this letter．

In English，digraph spellings aren＇t very predictable．There are hints of a pattern in the fact that the digraph spellings of the fricatives $/ \theta / / / \delta /$ ，and ／f／（＜th＞，＜th＞，and «ph＞，respectively）consist of a letter that normally repre－ sents a plosive with a similar place of articulation followed by $\mathrm{h} \geqslant$ ．However，the first letter in the digraph spelling «sh＞of the fricative $/ \mathrm{S} /$ normally represents another fricative，not a plosive．Although many consonant digraphs in English have＜h＞as the second letter and a number of vowel digraphs have＜y＞，＜i＞， «w〉，or «u» as the second letter，some digraphs have other graphic patterns．In English，children may learn digraph spellings largely by rote．

In some writing systems，digraph spellings are more predictable phonologi－ cally than they are in English．For example，Hungarian palatal sounds（those that are pronounced with the front part of the tongue near or touching the bony roof of the mouth）are spelled with the letter for the corresponding nonpalatal sound followed by 〈y〉．This occurs in 〈gy〉，〈ny〉，and 〈ty〉．We might expect Hungarian children to take advantage of this pattern，given children＇s sensitiv－ ity to even rather subtle patterns，but we know of no research on this point．

## 11．8．3 Additional Complexities

Some writing systems，as mentioned in $\mathbb{\int}$ 2．6．2，group symbols for phonemes into units that correspond roughly to syllables．The correspondence between written syllables and spoken syllables is sometimes exact．When syllables have
codas, however, many such systems group those consonants with the syllable that follows the one they are pronounced in. In Kannaḍa, for example, the word /həlvə/ 'halvah' is spelled as in the top row of (4). The spoken syllable boundary falls between the two consonants (/həl.və/), but the way the word is written, the $/ \mathrm{l} /$ is grouped with the $/ \mathrm{v} /$. Cases of this kind, which appear in a number of other Indian writing systems as well, appear to cause difficulty for children (Nag et al., 2010).

```
(4) ळల్इ/həlvə/
    ळ/hə/ U्}/lva
```


### 11.9 Summary of Findings on Learning of Complex Patterns

Many phonographic writing systems, especially those that have existed for more than a few centuries, include complexities of one kind or another in the links between units of writing and units of language. The drive toward systematicity and regularity, in writing as in other human endeavors, is counteracted by other pressures, including a drive toward economy in speech and the greater conservatism of written than of spoken language. Because the forces that draw writing systems away from one-to-one relationships between sounds and phonograms aren't random, the complexities in writing aren't random either. Given the nature of sound change, for example, words that include a less common spelling of a phoneme aren't usually a random subset of all words that contain the phoneme. Instead, the less common phonogram tends to occur in particular contexts. Such patterns could potentially be useful to spellers, and we have seen that children learn to take advantage of them. Rote memorization is necessary in some cases, but it plays a smaller role than anticipated based on dual-route theory or the theory that spelling involves primarily rote memorization.

The results we have reviewed fit well with IMP's view that children use patterns that extend beyond specific words to motivate spellings stored in memory and to construct new spellings $(\$ 4.6)$. Knowledge of patterns helps children to learn and remember words that conform to the patterns, although it can cause errors on words that deviate. The research findings are consistent with the idea that spellings that follow several patterns tend to be easier to learn and remember than spellings that conform to a single pattern or spellings for which patterns compete. The findings further show that many of the factors that affect spelling-including frequency, recency, and attentionare the same factors that affect learning and performance in other domains. For example, the fact that children pay most attention to the phoneme they are spelling and less attention to the surrounding segments helps to explain why some of the conditioned patterns we have discussed are learned slowly and incompletely. Spelling is influenced by linguistic knowledge as well as by domain-general learning principles. Thus, slow or incomplete learning of
certain patterns sometimes reflects a lack of linguistic knowledge, for example about the morphological structure of certain words.

According to phase theory $(\$ 4.4)$, young children rely on simple associations between phonemes and phonograms that don't consider graphotactics, morphology, or phonology. Developmental versions of dual-route theory ( $\$ 4.2$ ) make the same claim. However, the results we have reviewed show that even young children sometimes go beyond simple unconditioned rules that link phonemes to spellings. For example, children use their knowledge of certain graphotactic patterns to rule out some spellings and produce others. The results further show that there is a range of difficulty within each class of pattern. Children don't learn all phonological patterns at the same time. Nor do they learn all graphotactic patterns or all morphological patterns simultaneously.

### 11.10 Teaching

We have been discussing the sometimes complex links between spellings and sounds that are found in many phonographic writing systems. In this section, we ask whether children should be explicitly taught about these complexities. If so, how should this teaching work?

According to the whole-language view of literacy development ( $(\mathbb{1} \cdot 3.1$ ), children learn to deal with the complexities of sound-to-spelling translation on their own, as they try to spell and read words. Explicit instruction is unnecessary, even harmful. In contrast, advocates of direct instruction (\$1.3.2) maintain that children should be explicitly taught about some of the complexities of their writing systems. Phonics, one approach to direct instruction, teaches some of the complexities discussed in this chapter by means of generic statements. For example, children are told that English $/ \mathrm{S} /$ is spelled as 〈sh». However, many of the patterns discussed in this chapter aren't usually taught in schools. For example, children may not be taught that English /k/ is spelled with «ck» in the final position of a word after a single vowel letter and with 〈k> after two vowel letters. They may not be taught that /ən/ is usually spelled as <ion> in abstract nouns that are derived from verbs (e.g., education) and as <ian> in nouns that are derived from other nouns (e.g., magician). Students in phonics programs are often taught to divide spoken words into phonemes as a preparation for instruction in phoneme-to-letter links: phonemic analysis. Less attention is usually devoted to dividing spoken words into morphemes.

The evidence we have reviewed shows that children learn some complex spelling patterns on their own, without direct instruction. But this doesn't mean that instruction has no role to play, for learning without direct instruction is often slow and incomplete, resulting in knowledge that is tightly tied to the specific instances that were learned. Children benefit from instruction about the simple and widely applicable patterns that are typically covered in basic phonics instruction. They also benefit from instruction about more complex phonological, graphotactic, and morphological patterns, including the
patterns involving English /k/ and /ən/ just mentioned (Nunes \& Bryant, 2009; Nunes, Bryant, \& Olsson, 2003). Indeed, in one study, British 8 -year-olds progressed more rapidly in spelling when given instruction that emphasized morphology than when given instruction that emphasized relations between phonemes and letters (Devonshire \& Fluck, 2010).

It isn't realistic or useful to explicitly teach every pattern in a complex writing system, especially since some patterns apply to small sets of words. However, teachers can help children to understand that some sounds have more than one possible spelling and that different spellings may be appropriate in different contexts. Teachers can demonstrate that words that don't fit simple unconditioned rules that relate spellings and sounds may nevertheless follow other patterns and that it is useful, even fun, to learn about those patterns. For example, a teacher who understands the patterns of English can explain to students not just that the spelling «giv» is incorrect but why: English words rarely end with $\langle\mathrm{v}\rangle$. The teacher can help students to find other words that have an «e» after what would otherwise be a final «২〉, including «have» and «live». If an astute student notes that the spelling «Luvs» is used for a brand of diapers, teacher and students can discuss the unusual spellings in the names of some commercial products.

One method of direct instruction is to get children to change their pronunciations of some words for purposes of spelling. For example, rather than teaching German children that $/ \int /$ is spelled as <ch in words that come from French, rather than with the <sch that is typical for German, children can be taught to pronounce champignon and similar words with $/ \mathrm{x} /$, which at the beginning of words sounds similar to $/ \mathrm{S} /$. Using this spelling pronunciation (a new or artificial pronunciation formed by reading a word with more typical letter-sound correspondences), children could spell the word via a rule that applies to many German words: /x/ corresponds to «ch». In one study, German children spelled borrowed words like champignon better if they were taught to produce spelling pronunciations than if they weren't (Landerl, Thaler, \& Reitsma, 2008). In another study, however, German children didn't benefit from spelling pronunciations like /'mann/ for native words like Mann 'man', which is normally pronounced /man/ (Thaler, Landerl, \& Reitsma, 2008). Using a spelling pronunciation requires learning a new pronunciation for a word, which may not be easier than learning a spelling. Learning a new pronunciation may be particularly difficult when that pronunciation doesn't fit the typical phonological patterns of the language, as with a pronunciation like /'mann/ in German.

### 11.11 Conclusions

The ideal phonographic writing system, we often think, has simple, one-toone links between sounds and spellings. Most alphabets don't meet this ideal, and some syllabaries don't either. Across writing systems, complex links are
more common in the sound-to-spelling direction than in the spelling-to-sound direction.

In this chapter, we reviewed the research on how children deal with these complexities. The results support IMP's view that children use domain-general learning skills, together with knowledge about language, to learn about the patterns in spellings. Some parts of some spellings are difficult to motivate and require a degree of rote learning. However, many spellings-more than expected on the basis of dual-route theory and more than appreciated by some teachers-make sense on the basis of phonological, morphological, and graphotactic patterns. Although children learn some of these patterns without explicit instruction, direct teaching can help them to learn more effectively and efficiently.

MOST ASPECTS OF WRITING represent units of language. In previous chapters, we concentrated on how children learn about these aspects. But writing has a life of its own, in that some of its graphic symbols and conventions don't transcribe language directly. Nothing in language corresponds to such things as colons, semicolons, parentheses, italics, indentation, or putting one's name at the top of one's homework. These features of written language aren't glottographic, as most others are. They reflect people's views of the logical organization of the ideas. Many of them are best seen as semasiographic ( $\mathbb{\$ 2 . 2 . 1 ) \text { , representing }}$ ideas directly rather than through language. Such features of written communication as punctuation marks, paragraphing, and spacing between words are valued because they make the structure of the message clearer. They help to compensate for the fact that writing underrepresents linguistic informationfor example, that it doesn't signal intonation and, in many systems, suprasegmental information such as stress. These features also help to compensate for the fact that writing doesn't reproduce the gestures and facial expressions that people produce when they speak.

In this chapter, we discuss punctuation and capitalization, features of writing that are used by many but not all written languages. We include under the rubric punctuation techniques for separating words. This usage may seem odd because in most modern scripts word separators have no visual form other than the space they occupy. However, in all respects other than being invisible, spaces behave like punctuation marks, making writing more intelligible by separating streams of letters into discrete units.

Topics such as punctuation and capitalization haven't been the subject of much behavioral research, and some of the research that has been done is preliminary or anecdotal. Nor have these topics have been the subject of much theorizing. The theories that we reviewed in chapter 4 concentrate on how children use phonograms to transcribe language; most have little to say about punctuation or capitalization. Although there are many open
questions, the theoretical framework that guides this book, IMP ( $\mathbb{4} 4.6$ ), applies to punctuation and capitalization as much as to the learning of spelling per se. The research that we review in this chapter suggests that children learn about certain formal patterns involving punctuation and capitalization from an early age. The patterns that children acquire early tend to be ones that require a minimal degree of linguistic knowledge and that can be learned on a purely graphic basis. Other patterns involving punctuation and capitalization require a high degree of linguistic knowledge, and these take longer to learn.

### 12.1 Punctuation

As a foundation for considering how children learn about punctuation, it is useful to consider its history. Punctuation has had a checkered history. The Mesha inscription, which was written in Phoenician script in the ninth century b.c., was carefully punctuated with dots <.> between words and vertical lines <.> between sentences. But a thousand years later, Latin and Greek manuscripts and inscriptions rarely used any marks of punctuation; even words were run together without separating them in any way. Punctuation found in old manuscripts was typically added not by the scribe but by the owner. Readers had to prepare carefully before they could read a text aloud with appropriate expression. They sometimes placed small marks in the text as reminders of how to break up the text and where and how long to pause.

Even today, the roles of such marks as commas, periods, and semicolons are sometimes interpreted in terms of intonation and pausing while reading. According to this intonational view of punctuation, a comma marks the end of a breath group, a short pause; a semicolon marks a somewhat longer pause; and a period marks a long pause. However, the prevalent view of punctuation nowadays is that it should mark grammatical function. For example, in a sentence like "I love commas, semicolons, and colons," the commas (at least the first one) are required in order to show coordination between the three components, regardless of whether the writer actually imagines the reader will pause at the commas. Some distinctions in modern punctuation never correspond to distinctions in intonation. "He reported the decision: we were forbidden to speak with the chairman directly" means something different from "He reported the decision; we were forbidden to speak with the chairman directly" (Nunberg, 1990). However, the two different meanings don't correspond to two different intonations.

Virtually all writing systems in current use include punctuation. But punctuation is sometimes omitted in actual use. In the United States, a textual signal telling pedestrians not to cross the street may say DONT WALK, without an apostrophe. Adult writers of Spanish may in informal writing or text messaging omit the $\rangle\rangle$ that is required at the beginning of questions. A tendency to omit punctuation is furthered by the fact that there are often other ways to
convey the structure of a text．Consider this sign at a construction site（1）．There is no punctuation after STOP，but the line break suggests that that word is to be treated as a complete sentence：＂Stop！＂

## STOP <br> ALL VISITORS MUST REPORT TO SITE OFFICE

Given the fluidity of punctuation，its use becomes a matter of personal style． Some people express surprise in email messages by writing several exclama－ tion marks in a row；other people never use this form of punctuation．The style of one of this book＇s authors originally included semicolons and colons；that of the other author lacked them；our joint style includes some of these marks， although normally not to excess．

## 12．1．1 Punctuation Marks

The visual characteristics of many current Western punctuation marks reflect their history：Readers had to use small and simple symbols（Latin puncta ＇points，dots＇）that could be squeezed between letters in texts that had already been written without punctuation．Most punctuation marks are thus smaller than letters，with fewer segments．The most common punctuation marks， namely the period and the comma，are among the smallest．Further reflecting their history，some punctuation marks，including quotation marks and apos－ trophes，aren＇t set on the line of print．Indeed，some punctuation marks are similar to diacritic marks in their location as well as their size or shape．An English apostrophe，for example，is virtually identical to the Czech háček dia－ critic as it appears in printed forms after some letters：〈d〉．Even those punctua－ tion marks that look fairly similar to letters，including «？» and «！»，have some different graphic properties than letters do．They are more likely than letters to consist of unconnected parts，and they are less likely than letters to contain closed portions．

Nonwestern writing systems have borrowed Western punctuation marks． For example，many of the punctuation marks used today in Chinese were bor－ rowed from Western ones．Their shape wasn＇t adapted to fit the design prin－ ciples of Chinese，contrary to what often happens when symbols are borrowed （chapter 8）．Symbols such as «？» and «！＞used in Chinese look quite different from logograms such as 衣＇clothes＇．That incongruity is tolerable and per－ haps even desirable because the punctuation marks have different functions than the logograms．Some punctuation symbols in Chinese look somewhat different from the corresponding Western ones but still quite distinct from the characters．The main such difference is that the end of a Chinese sentence is marked by a small open circle，a little larger than the Western symbol．In every－ day handwriting，however，Chinese people may use a dot．Punctuation marks are allotted an entire character space in Chinese，and periods and commas
may appear at the left edge of this space or in the middle．A small punctuation mark that has blank space on one or both sides，set in a evenly spaced string of characters，stands out visually in traditional Chinese（2）more than it does in the equivalent English text（3）．
（2）猫，狗，鱼
（3）cat，dog，fish
Punctuation marks aren＇t iconic，in that their shapes don＇t reflect their functions．But people sometimes introduce motivations of their own．One boy explained the shape of quotation marks by saying＂they use lines because when they talk it＇s like lines come out of their mouth＂（Wilde，1992，p．3）．The sym－ bols that people have developed to express emotion in writing，which function somewhat similarly to punctuation marks such as «！»，are somewhat iconic．It makes sense that（4）symbolizes happiness if the reader tilts his head to the left，the Western convention．The Japanese convention that the head isn＇t tilted helps to motivate（5）for＇wink＇．
（4）：）
（5）＾＿～
We saw in chapter 9 that the names of letters usually reflect their linguistic functions．Specifically，the name typically contains the phoneme that the letter represents．The names of many punctuation marks also reflect their functions． For example，the term full stop is used in England for the mark that appears at the end of a sentence and that，according to the intonational view of punc－ tuation，signals a long pause．Another function－based name that is heard in England is speech mark．The US labels for these symbols，period and quotation mark，respectively，are also based on function but in a less obvious way．Some function－based labels are transparent to adults but not to children，including exclamation mark．Other labels，although originally based on function，are now obscure to both children and adults．The words comma，colon，and period are all terms defining units of speech in the ancient Greek theory of oratory，but few people know this now．

Although the names of letters don＇t usually signal the letters＇shapes，the names of punctuation marks often do．For example，the mark that appears at the end of a sentence is called＇dot＇in many languages：point in French，tečka in Czech，and piste in Finnish．In French，the colon is called deux points＇two dots＇．The cover term for punctuation marks sometimes reflects their appear－ ance as well，as with the Finnish välimerkki，literally＇in between mark＇，and the Latinate word punctuation，literally＇adding points＇．

The names of punctuation marks are usually longer than the names of let－ ters．They are also less similar to one another．There may be some degree of phonological similarity，though，in that the names of several symbols may contain the word for＇mark＇or＇dot＇．Whereas letters rarely have more than one widely used name，punctuation marks sometimes do．In England，for exam－ ple，one may hear the shape－based names sixty sixes and ninety nines and the
function－based names opening quotation marks and closing quotation marks to refer to the same marks．

Given this background on the shapes and names of punctuation marks，we turn to the question of how children learn about punctuation．Whereas parents sometimes talk about letters of the alphabet with their preschool children，they rarely talk about punctuation．Examining all of the conversations between US parents and their 1－to 5 －year－old children transcribed in the CHILDES database （MacWhinney，2000），we found that the only punctuation marks that parents mentioned more than once were the period and，in second place，the question mark．The two least common letters of English，«Z〉 and «Q»，received 58 times more mentions than these two punctuation marks．

Learning about punctuation marks involves learning that they belong to a different set from letters．The fact that young children don＇t hear their names very often may encourage this idea，together with the fact that punctuation marks don＇t appear in listings of the alphabet．In addition，as mentioned above，punctuation marks look somewhat different from letters and their names sound rather different．Some young children have been reported to visually distinguish letters and numbers from periods，colons，hyphens，and ellipsis points－those punctuation marks that are made up of single lines and dots（Ferreiro \＆Teberosky，1982）．According to this report，5－and 6－year－olds have trouble with punctuation marks that look more similar to letters，some－ times taking them to be letters or digits（6）．

$$
\begin{array}{ll}
? & \rightarrow  \tag{6}\\
; & \quad \mathrm{i} 5 \mathrm{~S} \\
\end{array}
$$

Although the small size of many punctuation marks probably helps chil－ dren to learn that they form a separate class from letters，it can cause them to overlook the punctuation marks．When the 5 －and 6 －year－olds in one study were asked to copy a text，they sometimes failed to copy the punctuation marks（Gòes \＆Martlew，1983）．The children were more likely to omit peri－ ods，commas，and ellipsis points－the smaller punctuation marks－than to omit question marks and exclamation marks－the larger and more letter－like punctuation marks．

We saw in $\int 8.2 .2$ that children sometimes confuse letters that differ only or primarily in position relative to the line of print，such as the Hebrew 7 ／kaf so＇fit／and ר／rej§／，and letters that differ in rotation or orientation，such as 〈b＞and 〈d»．Some pairs of punctuation marks differ only in these ways．For example，the comma＜＜＞and the apostrophe $\langle<\rangle$ differ only in their location rela－ tive to the line of print，and «？＞and 〈 $\rangle$ are turned versions of each other．We would expect children to confuse these marks，but we know of no systematic studies of this issue．Anecdotal evidence comes from the 8 －year－old who wrote ＜lm，＞instead of 〈l＇m＞（Martens \＆Goodman，1996）．The child seemed to know that the shape of the required punctuation mark but not its position relative to the line of print or relative to the other letters．

Few studies have examined how children learn the names of punctuation marks. According to one study, US 7 -year-olds are better at naming periods than other punctuation marks (Milligan, 1941). One reason for this may be that, as mentioned earlier, adults talk about periods more often. Another reason may be that periods are more common than other punctuation marks in reading materials designed for young children. Although we know of no published research on this topic, we found in examining a corpus of books for Czech children (Kessler \& Caravolas, 2011) that periods were substantially more frequent than commas in books for 6 -year-olds. In books for older children, the pattern began to reverse. We suspect that the same patterns hold true in other languages. Young children who have little experience with the conventional names of punctuation marks may invent their own. Thus, Spanish-speaking prereaders have been observed to use the terms puntitos 'little dots' and rayitas 'little lines' for punctuation marks that are made up of dots and straight lines, respectively (Ferreiro \& Teberosky, 1982). Once children learn some of the conventional names for punctuation marks, they may use the name of one mark for a visually similar mark. Thus, just as children may call the letter «h» by the name of «n», so they may call an apostrophe a comma. Children's errors in labeling punctuation marks also reflect the phonological complexity of some of the names. Thus, one child called an apostrophe a catastrophe (Lamme, 1984) and another child, evidently confusing apostrophe with the phonologically similar apostle, said that an apostrophe is a follower of Christ (Bryant, Devine, Ledward, \& Nunes, 1997).

We turn now to studies of the use of punctuation marks in writing. Learning to use the marks correctly is difficult, and US children appear to make more errors in punctuation than in spelling (Wilde, 1988). The errors that children make in punctuation are often omissions. Children are more likely to omit a required punctuation mark than to use one that isn't needed (Geoghegan \& Fitzgerald, 1935; Wilde, 1988). Contributing to these omissions is the small size of the punctuation marks and the fact that a good deal of linguistic knowledge is required to understand some of the patterns involving their use.

To examine the learning of specific punctuation marks, we begin with the one that is most common in reading materials designed for young children, the period. IMP $(\mathbb{\$} 4.6)$ predicts that children learn about salient visual patterns involving the symbols of writing on a graphic basis, even before they understand the symbols' functions. Thus, it is important to understand the visual patterns that involve periods. Most texts written in languages that go from left to right have a period immediately to the right of the rightmost letter on the bottom line of print. Such text-ending periods are more visually obvious than internal periods, which have less blank space around them. Some books for children have a single sentence on each page, meaning that each page has a period to the right of the rightmost letter. When a children's book has more than one sentence on a page, each sentence may begin on a new line. In this case, each line normally has a period to the right of the rightmost letter. When a line of print includes more than one period, these are usually separated by at least several letters and spaces. Rarely are periods adjacent to one another or
separated by just one letter. A period in the middle of a line of text is usually followed by a blank space and then an uppercase letter.

The research on children's use of periods, sparse though it is, supports IMP's prediction that children learn about common visual patterns involving periods from an early age. When 5- to 8 -year-old learners of English include periods in their writing, either on their own or after being reminded to do so, they sometimes place them after the rightmost letter of the last word of the text, the last word of each page, or the last word of each line (Cordeiro, Giacobbe, \& Cazden, 1983; Edelsky, 1983; Hall, 1999; Vernon, Alvarado, \& Zermeño, 2004). Children seem to rarely place a period at the left edge of a closely spaced string of letters or in the middle of such a string, and they rarely use several periods in a row. That is, there are few reports of young writers producing such things as «.cat» or «c.at» or «cat..». These observations support the idea that children learn from an early age about some of the more obvious formal patterns involving punctuation marks. Indeed, children sometimes appear to treat the use of periods as a purely graphic matter, as with the British child who put a period halfway down a page before he wrote any words, announcing, "I've done my full stop" (Hall, 1999). Although some graphic patterns involving periods are learned at an early age, not all are. Uncommon and visually subtle patterns, such as the fact that periods generally precede closing quotation marks in American English, cause difficulty even for adults.

The most common function of the period is to signal the end of a declarative sentence. Periods also appear after some abbreviations such as «Prof.» and in some initialisms such as «U.S.», especially in more traditional US usage. Learning about the sentence-ending function of the period requires knowledge of a linguistic concept, the sentence. This concept is difficult for children, in part because conversational speech is often structured in terms of clauses. Teachers often tell children that they should use a period at the end of each sentence, but even children who can state this rule may place periods incorrectly, putting them for example at the ends of sentence-internal clauses. Thus, the US primary school students in one study wrote such things as «I went downtown. with my mother.> (Cordeiro, 1988). Just as spelling words in alphabetic writing calls on one type of linguistic knowledge-knowledge of phonemesso use of periods calls on another type of linguistic knowledge-knowledge of sentences. Just as learning to spell words heightens knowledge of phonemes (chapter 13), so may learning about periods and other sentence-final punctuation marks heighten knowledge about sentences.

Commas are more difficult than periods, in that children are more likely to omit required commas than required periods (Wilde, 1988). For younger children, this may reflect the lower frequency of commas in the writing that they see. Also, we suspect that teachers and other adults place less emphasis on commas than periods, at least with younger children. The visual salience of commas may be lower, too: Commas never appear at the end of a text but are always buried within it. The primary reason for the comma's difficulty, however, probably lies in the multiplicity and complexity of its linguistic functions. Commas
are used to separate clauses，to separate items in lists，to indicate that a word has been omitted，and for other purposes as well．Even good adult writers don＇t always agree with one another or with themselves about the use of commas．

Children sometimes use a comma rather than a period at the end of a declarative sentence（Geoghegan \＆Fitzgerald，1935）．They seem to be par－ ticularly prone to do this when the sentence is followed by another on the same or a closely related topic．For example，an 8 －year－old who was writing about a school trip used periods to set off different episodes within a trip，such as getting on a bus，traveling on the bus，and so on（Kress，1982）．The child used commas within each episode，as in＂We＇re off I thought，there was lots of merry talk in the bus．＂Experimental evidence for this point comes from a study in which French 8－and 9－year－olds wrote about their school schedules． They tended to place within the same sentence all of the subjects that were studied on the same day，and they sometimes failed to use any punctuation to separate the subjects that were studied within a relatively short stretch of time， such as within the same morning（Chanquoy，1988）．

Several studies have examined another punctuation mark，the apostrophe． In English，an apostrophe may occur at the right edge of a string of letters，as in «ships＇〉．An apostrophe may also occur one or two letters away from the end of a word，as in «ship＇s» and «she＇ll»．Apostrophes don＇t usually appear in other positions．Whereas the distribution of periods and commas isn＇t conditioned on the adjacent letters，the distribution of apostrophes is．In English，apostro－ phes that occur at the ends of words are almost always preceded by 〈s〉．Those in the second－to－last position of a word mainly occur after «n» and before＜t＞， as in «shouldn＇t＞，or before 〈s $\rangle$ ，as in «ship＇s ．Those in the antepenultimate position precede «ll»，as in «we＇ll»．IMP suggests that children may learn about some of these graphic patterns from an early age．Research evidence is scarce， but we have seen no reports of children making errors such as 〈do＇g＞for dog but a number of reports of errors such as «week＇s» for weeks and 〈like＇s» for likes （Bryant et al．，1997；Bryant，Nunes，\＆Bindman，2000；Cordeiro et al．，1983）． Indeed，adults sometimes produce graphically correct but wrong apostrophes when they write such things as «apple＇s for sale» instead of «apples for sale»．

In English，apostrophes have two main functions．The first is to signal con－ traction，or the omission of letters in a written form，as in let＇s go and wouldn＇t． The second is to mark possession，as in the cat＇s meow．Apostrophes before＜s＞ are ambiguous in that they can mark either omission or possession and in that they can signal the omission of different letters，including the omission of 〈u» from $u s$ as in «let＇s〉，«i» from is as in «she＇s nice»，or «ha〉 from has as in ＜she＇s got it＞．Apostrophes before letters other than «s〉 are less ambiguous in that they only mark contractions．In a number of these cases，the apostrophe signals missing letters from just one word．For example，«n’t is a contraction of not and of no other word．Another difference between contractions involving ＜ S$\rangle$ and contractions involving other letters is that omitting the apostrophe in a contraction involving «s〉 sometimes yields a word，as in lets for let＇s or its for $i t$＇s．Omitting the apostrophe in a contraction that involves a letter other than

〈S〉 rarely yields a word．Indeed，it sometimes yields a graphotactically illegal sequence such as «shouldnt» or «theyll»．These considerations help to explain why children find «n＇t» contractions easier than «＇s〉 contractions（Stuart，Dixon， \＆Masterson，2004）．

Children appear to have more difficulty with apostrophes that signal posses－ sives than those that signal contractions（Bryant et al．，1997；McMillan，1999； Stuart et al．，2004）．Thus，they omit the required apostrophe before $\langle\mathrm{s}\rangle$ in a possessive like week＇s work more often than they omit the required apostrophe before the＜s＞in a contraction like where＇s．The difference probably reflects the fact that weeks is a common word，the spelling of which children may have stored in memory．Wheres isn＇t a word．As we saw in previous chapters，errors are more likely to occur when they result in words and in graphic sequences that resemble words than when they don＇t．

Within the category of possessives，spellers of English make more errors on plurals than on singulars（Hokanson \＆Kemp，2013；Leong，2009）．They prob－ ably make more errors such as «week＇s for the plural possessive «weeks＇» than «weeks＇＞for the singular possessive «week＇s» because they have seen forms such as «week＇s» more often．

## 12．1．2 Word Separation

In the printed forms of English and many other languages，some letters－those that make up what is considered to be a word－are placed close together．They may even connect to one another in joined writing．Other letters are separated by noticeably larger gaps．These gaps indicate boundaries between words．

Spacing is a relatively new convention．Many ancient scripts had ways of graphically indicating where one word stops and the other begins，such as by put－ ting dots or vertical lines between words．The dot method is illustrated in（7）with the opening words of Caesar＇s De bello Gallico（＇The whole of Gaul is divided into three parts＇）．These conventions weren＇t always applied，and by the end of classi－ cal antiquity almost all text was written as scriptio continua，with no separation at all between words（8）．The idea of separating words with space began to catch on in Europe around A．D． 600 and has spread around the world（9）．
（7）GALLIA•EST•OMNIS•DIVISA•IN•PARTES•TRES
（8）GALLIAESTOMNISDIVISAINPARTESTRES
（9）Gallia est omnis divisa in partes tres
But even today，several orthographies don＇t separate words in any way．In Chinese and Japanese，each symbol has a fixed space．The spaces between sym－ bols are no larger when two adjacent characters are two different words than when they are part of the same word．In Vietnamese，a space is put between each syllable，but no extra space is put between words．

People have an intuitive understanding of what a word is，and orthographic traditions for placing spaces between words generally follow those intuitions． There are，however，many vexing situations in which it is difficult to secure
universal agreement on whether something should be treated as one word or a sequence of two words with a space between them. In English, for example, two words may be combined to form a compound word. Sometimes compound words are conventionally written with no space in them, as in bluebird, and sometimes a space is required, as in blue jay. There are many rules for distinguishing between these cases, but the most honest lists of such rules include the escape clause "check a dictionary."

Another major problem for applying interword spacing is the status of grammatical morphemes. Short function words such as the, in, and, is, and you don't behave like full words in some ways. Because they are typically unstressed and often take fixed positions with respect to the word they are associated with, they may seem somewhat like affixes rather than words in their own right. It isn't surprising, therefore, that some orthographic traditions choose not to place a space between them and the word they seem to attach to. Spanish, for example, writes object pronouns such as te 'you' separately before the verb, as in te come 'it eats you', but attached to the verb when following it, as in comerte 'to eat you'. In Hebrew, the article /ha/ 'the' is attached to the following word without a space (10). The same is true of the Arabic article /al/ (11).
(10) הארץ /ha'Tarets/ 'The Land’
(11) الجزيرة /alđЗazi:ra/ 'The Peninsula’

In some languages, hyphens offer an intermediate solution between separating words and joining them into one. Here, too, there are variations within and across languages. Where Spanish attaches a pronoun directly to a preceding verb (12), the same command is expressed in French with the help of a hyphen (13), and English inserts a space (14).
(12) ayúdame
(13) aide-moi
(14) help me

Some 5- and 6-year-olds don't reproduce the spaces between words when they are asked to copy a printed text (Gòes \& Martlew, 1983), and some children of this age don't use spaces to separate words when they write their own texts (Sandbank, 2001). Visual and motoric considerations probably contribute to these failures. The spaces that indicate word boundaries, although larger than the spaces between letters, aren't substantially larger. Thus, they are somewhat difficult to see and to reproduce. This doesn't appear to be a complete explanation, though, for children may produce the correct spacing when copying a text even when they don't use it when writing dictated texts or composing their own stories (Roberts, 1996).

When children do begin to use some word spacing in their writing, they don't always insert spaces in the way that is conventional in their orthography. For example, children may often omit spaces next to function words. The Spanish-speaking 7 - to 9 -year-olds in one study produced such errors as <ala casa> for a la casa 'to the house' and «sele> for the two pronouns se le (Ferreiro
\& Pontecorvo, 2002). Joining of grammatical words was also reported in a study in which US 5 - to 8 -year-olds were requested to write "The lady planted many pretty trees in her garden." The children's most common spacing mistake was to join in and her (Roberts, 1992). In another study, children were more likely to put a space between a noun phrase and a verb phrase, a major boundary in the grammatical structure of a sentence, than to put spaces within a verb phrase. For example, one child wrote 〈losrelles letragiero» for los reyes le trajeron 'the kings brought him' (Edelsky, 1983). In addition, a group of words that often appears together may resist segmentation. For example, US children may write <wasapanataem> for once upon a time (Harste, Woodward, \& Burke, 1984) and Spanish-speaking children may do something analogous for the Spanish equivalent, había una vez (Clemente, 1984). Similarly, Italian 7 - to 9 -year-olds sometimes write <perfavore> instead of <per favore> 'please' (Ferreiro \& Pontecorvo, 2002). Some errors involving spacing are quite persistent, with even skilled writers of Spanish sometimes making errors involving pronouns and prepositions and even skilled writers of English sometimes making errors like <incase> for in case.

Failures to separate words are more common in beginning writers than splitting words (Correa \& Dockrell, 2007; Ferreiro \& Pontecorvo, 2002). Sometimes, though, children break up what their language considers to be a single word. Quantitative studies of such errors are rare, but a number of the examples that have been reported involve divisions of words at morpheme boundaries. A Spanish example is <comer te> 'to eat you' instead of attaching the pronoun to the verb, «comerte> (Ferreiro \& Pontecorvo, 2002). «Nueva mente» for nuevamente 'again' is another error that involves division at a morpheme boundary (Ferreiro \& Pontecorvo, 2002). The suffix -mente converts an adjective (nueva 'new') into an adverb; with a space, the word mente means 'mind'. Some errors break up morphemes, as when Spanish-speaking children write grande 'large' as «gran de» (Ferreiro \& Pontecorvo, 2002). The word «de» 'of' is common in Spanish, and even young children may be familiar with it as a single word. According to IMP, errors that break up morphemes should be more common when they result in well-known spellings such as these than when they don't. This prediction, to our knowledge, hasn't been tested experimentally.

There are scattered reports of children appropriating devices other than spacing to separate words, including periods and plus signs, or of developing their own graphic symbols for this purpose, such as darkened squares (Martens \& Goodman, 1996; Rowe \& Harste, 1986). Other children have been observed to place each word of a sentence on a separate line or to draw circles around the letters that belong to the same word (Lamme, 1984).

### 12.2 Capitalization

The Latin alphabet and certain other alphabets have separate sets of uppercase and lowercase letters. Writers are supposed to use an uppercase letter
for the first letter of a word, or capitalization, to mark certain distinctions. One function of capitalization is to indicate the beginning of a sentence. Another function is to mark the first word of each line in certain forms of poetry, even if that word doesn't begin a sentence. Capitalization also marks proper names such as Africa and, in many languages, words derived from them, such as African. In German, capitalization marks all nouns. Many languages also capitalize important words in a title. In English, the first person pronoun $I$ is also capitalized, as are the names of days of the weeks, months, and languages. It is uncommon for a letter other than the first letter of a word to be capitalized, although this does occur in personal names such as McGibbon and product names such as AstroTurf. Capitalization, like punctuation, is somewhat fluid. This fluidity makes it available for personal expression. Some people omit capital letters in informal communications, and E. E. Cummings famously used unconventional capitalization in his poetry.

Some aspects of capitalization can be learned on a graphic basis, without attention to function. One such pattern is that the leftmost letter of a text is often in uppercase. Within a text, an uppercase letter usually appears to the right of a blank space and to the immediate left of a lowercase letter. By the age of 5 or 6 , before they have been formally taught about these patterns, US children are more likely to use an uppercase letter at the left edge of a word than in the middle or at the right edge when writing single words to dictation (Treiman, Berch, \& Weatherston, 1993; Treiman \& Kessler, 2004). When children of this age occasionally capitalize a noninitial letter of a word, this is sometimes the first letter of their given name, a letter that they often see and write in uppercase. Thus, Dayna may occasionally write word as «wrD», using the same uppercase <D> that she uses in her name (Treiman \& Kessler, 2004). When writing more than a single word, 7 -year-olds are more likely to use a capital letter at the beginning of the text than after a period within the text (Vernon et al., 2004).

Although children learn at an early age about some of the formal patterns involving capitalization, they take longer to learn about its functions. Nine- to twelve-year-old learners of English don't always use an uppercase letter to begin the first word of a sentence, even after they have been explicitly taught to do so. Children make more errors on this aspect of capitalization than on such things as using a capital for «I> or for days of the week (Geoghegan \& Fitzgerald, 1935; Odom, 1962). The difference probably reflects the fact that the first letter of a word like Wednesday always appears in uppercase. But candy is capitalized in some cases-at the beginning of a sentence or when a proper name-and not in others. In such cases, writers can't unthinkingly use a fixed graphic form that they have stored in memory. They must consider the grammatical context in which the word appears and its meaning. As we saw in earlier chapters, it is more difficult to use context to select among alternatives than to use the same spelling every time.

### 12.3 Teaching

Punctuation and capitalization, as we have seen, can be difficult to learn. Should children receive explicit teaching about these matters? If so, what sort of teaching is best? The whole-language approach ( $\$ 1.3 .1$ ), with its focus on discovery, makes the same claim about the learning of punctuation and capitalization as it does about the learning of spelling. This claim is that children learn as they are exposed to print and as they attempt to make sense of how it works. Explicit teaching is considered unnecessary, even harmful. According to Goodman (2005, p. 79), punctuation is, in any case, "virtually impossible to teach."

The research we have reviewed shows that children make some progress in the absence of explicit instruction. For example, we saw that US 5 - and 6-year-olds are more likely to capitalize the first letters of words than the later letters before they have received explicit instruction about capitalization. Similarly, British children may know some things about apostrophes before they have been formally taught about their use (Stuart et al., 2004). Children may learn these things, in part, through reading. To maximize the amount that children learn about punctuation through reading, it could be helpful in books for children to make small punctuation marks a little larger than they normally are. It could also be helpful to use relatively wide spacing between words and relatively close spacing within words, although not so close that the letters are difficult to make out.

Although children learn some things about punctuation and capitalization without explicit instruction, learning can be speeded through well-designed direct instruction ( $(\$ 1.3 .2)$. Contrary to the claim of Goodman (2005), punctuation isn't virtually impossible to teach. In one study, for example, a half hour of instruction helped 9- to 12 -year-olds use possessive apostrophes (Bryant et al., 1997). Effective instruction includes the components that are discussed elsewhere in this book, including statements of rules, practice with examples, and comparisons of examples that do and don't fit rules (Nunes \& Bryant, 2009).

Teaching of punctuation and capitalization draws on linguistic concepts that are unfamiliar to young children-unfamiliar, in part, because they are built on knowledge of literacy. For example, the concept of a sentence is based in part on knowledge of writing. A child who doesn't yet know how to read and write may not understand a teacher's generic statement that sentences should end with periods. The child may take the direction to use a period "at the end" to refer to the end of a unit that is more concrete than a sentence, such as the end of a line of text. The concept of a word, too, is partly based on writing. A child who doesn't yet know how her writing system defines words may not understand what the teacher means when he says to leave a space the size of a finger after every word. It is natural to assume that others share one's ideas. Teachers may make this assumption in the case of words and sentences, not realizing that their own ideas about these matters are based in part on their knowledge about writing. Teachers who can put themselves in the place of
their students can provide more effective instruction and respond more effectively to students' errors.

### 12.4 Conclusions

In this chapter, we have reviewed the relatively small body of research on children's learning of capitalization and punctuation, including word separation. Some aspects of capitalization and punctuation can be learned on a graphic basis and don't require any special knowledge about language. Children begin to learn about these aspects at an early age, even without explicit teaching. For example, children can notice that a closely spaced string of letters is more likely to have an uppercase letter at the left edge than in other positions. Children are thus more likely to produce «Cat», with the leftmost letter capitalized, than «cAt». Other aspects of capitalization, punctuation, and spacing require linguistic knowledge. For example, learning when to use commas as opposed to periods requires knowledge about sentences. Learning the appropriate use of <cats〉, <cat's>, and «cats'> requires consideration of the word's role in the grammatical structure of the sentence. It can't be done by learning a fixed spelling for a specific sound sequence. These things may be difficult to learn even when they are explicitly taught.

Research on how children learn about capitalization and punctuation hasn't been well integrated with research or theory on how children learn to spell more generally. IMP offers the possibility of such integration with its distinction between learning about writing's outer form and learning about the linguistic functions of its units. Learning about writing's graphic form can begin early, as children employ the statistical learning skills that they use across a variety of domains. It doesn't require any special knowledge about language. Learning about the functions of writing's units often takes longer, for it rests on concepts about language that may be difficult or unnatural in the absence of literacy.

## CHAPTER 13 <br> Conclusions and Extensions

WRITING IS A TOOL that people have developed to help circumvent a limitation of spoken language: its natural evanescence. Using writing, people can convey information to others who are remote in time and space. Learning to write is a prerequisite for being a full member of a literate society. To write effectively, one must decide which ideas to convey, in which order, and with which words. One must arrange the words so as to express their meaning, following the constraints of the grammar. Writing the individual words correctly and following other orthographic conventions, such as the use of proper punctuation, are just part of the process. But they are an important part. A written message that falls short in these respects may be hard to read or may fail altogether to convey its intended meaning. Thus, it is important to understand how children learn to use their writing system to spell, punctuate, and so on.

We begin this chapter by evaluating the theories of spelling development that were introduced in chapter 4 . In each of chapters 5 through 12 , we discussed the theories in light of research on children's learning of the specific aspects of orthography covered in that chapter. Here, we attempt to draw together those discussions. We proceed to consider broader effects of learning a writing system-effects that go beyond learning how to use the system in order to produce written messages. This topic was only briefly touched on in previous chapters, and we review the research evidence on it here. In the final sections of the chapter, we turn to the topics of teaching and assessment, and we briefly consider why some children learn about orthography more easily than others.

### 13.1 Evaluation of Theories of the Learning of Orthography

A number of theories have been developed in an attempt to explain how children learn to use the writing system of their language. We may evaluate the
theories by asking whether they are consistent with the nature of writing systems, the nature of human learning, and the research findings on children's learning of orthography.

A traditional view, especially for languages such as English, is that children learn to spell by a process of rote memorization $(\mathbb{\$} \cdot 1)$. This view stems from the idea that spellings are basically arbitrary. Even in the most complex writing systems, however, spellings aren't as arbitrary as is often believed. Children needn't limit themselves to rote visual memorization and, as the research shows, they don't. Learners of English benefit, for example, from the fact that «spire» has common letter patterns: A number of other words end with <ire>. The <spire> spelling of /spais/ fits well with the graphotactic patterns of the English writing system; many words, for example, end in a vowel followed by a consonant and then «e». Children also benefit from the fact that <spire> includes common links between sound units and spellings. For example, a number of other words with /aus/ have the <ire> spelling. These graphic and phonological patterns make «spire» easier to learn and remember than <pqnuw> would be. Even words that are commonly considered to have exceptional spellings, such as want and choir, often follow patterns of their own. And patterns exist at other levels of writing as well. For example, the shape <L» has a graphic design that is typical of a number of Latin letters: a vertical line at the left and an appendage to the right. The name of this letter shape contains the sound that it represents, as do the names of many letters in many languages. From an early age, research shows, children take advantage of such patterns. Rote memory plays some role in learning to write words, but its role is smaller than often thought.

Dual-route theory ( $\$ 4.2$ ), which has been applied primarily to alphabetic writing systems, is based on the idea that the goal of such writing systems is to represent each phoneme with a unique spelling, or phonogram. Learning and performance will suffer whenever a writing system fails to meet this goal. We have seen, however, that writing systems are more complex than portrayed by dual-route theory. It is an oversimplification to classify spellings as either regular (those that follow simple rules linking phonemes to phonograms) or exceptional (those that deviate from those rules), in part because all deviations from one-to-one correspondences aren't equal in status. It is an oversimplification, too, to array writing systems on a single continuum from shallow (those with no deviations from one-to-one correspondences) to deep (those with many deviations). Deviations are of different types, and they have different consequences for the users of writing. Some deviations from simple unconditioned rules that link phonemes to phonograms reflect conditioned patterns. That is, a phoneme may have a different set of spellings in some positions or some contexts than in others. Children, we have seen, gradually learn about these patterns. In those alphabetic writing systems that show a degree of morphemic constancy-a tendency to spell a morpheme the same way even if it is pronounced differently in different words-the spelling of a phoneme or a phoneme sequence may depend on its morphological status. As we
have seen，children also pick up these patterns．Overall，the research findings don＇t support the idea that spellers are limited to either simple rules involving phonology or whole－word memorization．For some writing systems，the idea that phonograms behave as single units，on a par with individual letters，may also be incorrect．Developmental versions of dual－route theory，according to which young children rely heavily or exclusively on the nonlexical route，are also problematic．As we have seen，even young children store in memory the spellings of some important and familiar words．Dual－route theory represents an important advance over the traditional idea that learners must rely only on rote memorization．However，it doesn＇t acknowledge a number of the patterns that exist in writing systems，and it doesn＇t acknowledge that children learn these patterns．

Another theory that we considered，constructivist theory $(\mathbb{\$} 4 \cdot 3)$ ，is closely associated with Piaget＇s stage theory of cognitive development．Constructivist theorists propose that children go through a series of stages during which they hold qualitatively different hypotheses about the nature of writing．The hypotheses may go well beyond the input that the children have received．For example，learners of alphabetic writing systems are thought to go through a stage during which they believe that letters stand for syllables．Children do this even though they haven＇t been exposed to a writing system that works this way．As another example，children are thought to go through a stage during which they believe that all words must contain more than three or four letters，even when they have been exposed to a writing system that contains some one－and two－letter words．The research we have reviewed supports the constructivist idea that children in literate societies learn a number of things about writing before they are formally taught about it． Whereas the research supports certain of the constructivists＇claims about the nature of that knowledge，including the idea that children avoid produc－ ing repeated letters，it doesn＇t support many other claims．These include the idea that learners of alphabetic writing systems generally go through a stage during which they use letters to stand for syllables and that they go through a stage during which they believe that words must contain at least three or four letters．More generally，the research doesn＇t support the idea that children in modern literate societies construct ideas about writ－ ing that go substantially beyond the input．The apparent deviations that do occur can be explained in more prosaic ways．For example，the input that learners get isn＇t always representative of the writing system more generally． Five－year－old Zoe may think that 〈 Z 〉 is a common letter because her parents talk to her about this letter often，draw her attention to it on signs，and so on． When Zoe uses many 〈Z＞s in her spelling，she is faithful to her experience， if not to English more generally．

Stage theories have been largely rejected in other domains of cognitive development，partly because children don＇t show the high degree of con－ sistency in their thinking and behavior that such theories suggest（Siegler， 2007）．Another theory that we considered，phase theory（ $\$ 4.4$ ），rejects
the idea that children pass through rigid stages of development in learning to spell. Phase theory has been important in showing that, even after learners of alphabetic writing systems have grasped that letters represent phonemes, they produce a number of spellings that don't represent all of the phonemes in words. For example, limitations in children's phonemic analysis ability may cause them to produce spellings such as «bo> for blow. A limitation of phase theory, and one that has been acknowledged by some of its advocates (Wright \& Ehri, 2007), is that it underestimates the knowledge of graphotactic patterns that young children possess. Indeed, the research we reviewed shows that children in modern literate societies learn about some of the salient formal properties of writing from an early age. The research further shows that children don't always learn about the relationships between units of language and units of writing in the sequence proposed by phase theorists. For example, learners of alphabetic writing systems that show a degree of morphemic constancy appear to consider morphology when selecting among alternative spellings at an earlier point in development than phase theorists suggest. A further limitation of phase theory is that it groups together spellings that are rather different. For example, a child who produces spellings such as «ELFUNT〉 for elephant and <WOTRFLS» for waterfalls is considered to be in the same phase of development, partial alphabetic, as a child who produces <L> and <W> for these words. In many ways, however, the children are quite different.

Whereas dual-route theory sees spellers as using either entire spellings that have been stored in memory (for exception words) or simple rules linking sounds to phonograms (for regular words and nonwords, or novel items), connectionist theory $(\$ 4.5)$ postulates that spellers use a single method to spell all types of words and nonwords. A connectionist learning model is designed to pick up patterns in sound-spelling relationships-probabilistic and conditioned patterns as well as deterministic and unconditioned pat-terns-as it tries to spell words and receives feedback about whether its attempts are correct or incorrect. Connectionist models of spelling use the same statistical learning mechanisms that are thought to operate in a variety of domains. The results we have reviewed indicate that statistical learning plays an important role in learning to spell. The research shows that it is involved not only in learning the spellings of words, the topic on which connectionist models have focused, but also in learning about other aspects of writing, such as the visual characteristics of letters. However, we have seen that children aren't limited to learning from individual instances. Children also receive and learn from forms of explicit teaching that aren't available to current connectionist models, including verbal explanations that are provided by their parents and teachers. Moreover, children aren't ideal statistical learners. Their ability to learn about writing is slowed by limitations in their linguistic knowledge, including limitations in their ability to take language as an object and to analyze language into units. Learning is also influenced by children's cognitive limitations, including limitations in attention.

A further problem with current connectionist models is that they come to the task of learning to spell equipped with certain abilities that young children lack, such as knowledge of letter shapes. The models could potentially be expanded to cover this aspect of learning, but the current versions are in this respect unrealistic.

IMP, the theory that we advocate ( $\$ 4.6$ ), attempts to explain within a unified framework the learning of spelling and of other aspects of orthography, including symbol shapes and punctuation. IMP's central idea is that children use multiple sources of information: stored information about specific instances and patterns that go beyond specific instances. These general patterns can be of different types, including graphotactic, phonological, and morphological. Using general patterns allows children to go beyond rote memorization and, in some cases, to reconstruct missing information about instances. Children tend to perform well when multiple patterns support one another, as when a letter in a word's spelling or a group of strokes in a character is motivated by several different patterns. Children tend to have difficulty when different patterns suggest different spellings.

One type of general pattern, according to IMP, involves the outer form of writing ( $\$ 2.1$ ): what it looks like. Other patterns involve the inner workings of writing: how it functions to represent language. We have seen that children begin to learn about the outer form of writing even before they know that writing stands for language and how it stands for language. In order to learn about the patterns that relate form to linguistic function, however, children must know that writing represents language: that it is glottographic. They must treat spoken language as something that can be represented in a visual form. Depending on the nature of the writing system they are learning, children must also know that speech may be conceptualized in terms of phonemes, morphemes, words, and sentences. Limitations in linguistic knowledge can lead to slow or incomplete learning about the patterns that link units of writing to units of language.

Writing isn't part of the human genetic endowment, as spoken language is; it is an "optional accessory that must be painstakingly bolted on" (Pinker, 1997, p. ix). Consequently, children use mechanisms that evolved for other purposes in order to learn about the outer form and inner workings of writing. One of these is inducing general patterns from exposure to specific examples. Thus, Chinese children observe that some graphic units tend to occur in certain positions of characters and that other units tend to occur in other positions. Learners of alphabetic writing systems observe that words that contain a certain letter in their written form usually contain a certain phoneme in their spoken form. Another way that children learn about general patterns is by being told about them, as through generic statements. For example, children may be told that / m / is spelled as $\langle\mathrm{m}\rangle$ or that a certain group of strokes usually appears at the left side of a Chinese character. Such direct instruction speeds learning, reducing the need for children to induce patterns for themselves on the basis of exposure to multiple instances.

## 13．2 Broader Influences of Knowledge About Writing

To take full advantage of the benefits that writing offers，children must learn how their writing system works and how to use it．This is one reason to study how they do so．There would be even more reason to study the development of orthographic knowledge if children used this knowledge when doing things other than writing．In what follows，we review the evidence that they do．We will see that knowledge of spelling helps reading，influences language process－ ing more generally，and has some effects in nonlinguistic domains as well．

## 13．2．1 Influences on Reading

Learning to spell，punctuate，and so on not only improves the ability to write but also improves the ability to read．Research shows that knowledge of spelling shows some transfer to reading and that there is more transfer in the spelling－to－reading direction than in the reading－to－spelling direction （N．J．Conrad，2008）．Thus，children who are taught to spell specific words and who improve in their ability to do so usually get better，as well，at reading these words（Cunningham \＆Stanovich，1990；Rieben，Ntamakiliro，Gonthier， \＆Fayol，2005）．Spelling a word may facilitate later reading of that word even when a speller is prevented from seeing what she has written（Monsell，1987）． Transfer has been observed not only from spelling a word to reading that same word but also to reading other words（N．J．Conrad，2008；Ehri \＆Wilce，1987）． In one study，in fact，US 6 －and 7 －year－olds who were trained in spelling and in the analysis of spoken words into phonemes showed more improvement in reading than children who were trained in reading itself（Uhry \＆Shepherd， 1993）．Thus，orthographic knowledge is an important foundation stone for reading as well as writing．Time spent teaching children to write words can benefit their reading．

## 13．2．2 Influences on Language

Writing originally developed as a tool for circumventing the limitations of spo－ ken language．Once learned，it becomes a tool for thinking about language，for remembering the phonological forms of words，and for other purposes．It even has some influences on the form of language itself．

No writing system，as we discussed in $\mathbb{\int} 2.5$ ，reproduces language in its entirety．All underrepresent language to some degree．Writing highlights some aspects of language and conceals others．This influences the way in which people think about their language．Alphabetic writing systems highlight the level of phonemes．Thus，children and adults who know an alphabetic writing system perform well on tasks that require them to identify or manipulate pho－ nemes，provided that the answer that spelling provides is correct．For exam－ ple，English speakers may respond to the request to delete／f／from／fes／by deleting 〈f〉 from «face〉．That yields «ace»，which corresponds straightforwardly
to the correct answer, /es/. People may err in phonemic analysis tasks when spelling doesn't lead straightforwardly to the correct answer. For example, they may say that / wi $\theta$ / with becomes /wit/ when the last sound is dropped or that /sin/ sing contains four sounds rather than three. When people do respond correctly to such items, they may take extra time to do so. Such effects have been observed across a variety of languages and cultures and in both children and adults (Castles, Holmes, Neath, \& Kinoshita, 2003; Dijkstra, Roelofs, \& Fieuws, 1995; Lehtonen \& Treiman, 2007; Treiman \& Cassar, 1997). The influence of orthographic knowledge depends on the situation. If the participants in an experiment hear many words that they recognize as difficult to spell, for example, they appear to rely on spelling more than they would otherwise (Cutler, Treiman, \& van Ooijen, 2010).

Knowledge of a particular phonographic writing system promotes certain classifications of sounds and discourages others. For example, the English writing system promotes the idea that the vowel in the first syllable of /la'gun/ lagoon is /æ/. University students often judge that this word contains /læg/ even though, as usually pronounced, it doesn't (Taft \& Hambly, 1985). As another example, the English writing system encourages its users to place $/ æ /, / \varepsilon /$, and $/ \mathrm{l} /$ in one category (the so-called short vowels) and /e/, /i/, and /aI/ in another (long vowels). Alternations like those between «hatter» and «hater», «meddle» and «medium», and «bitter» and «biter» encourage people to relate $/ æ /$ to $/ \mathrm{e} /, / \varepsilon /$ to $/ \mathrm{i} /$, and $/ \mathrm{I} /$ to $/ \mathrm{ar} /$.

Literate people's judgments about rime, which is nominally based on phonological similarity, are also influenced by spelling. Thus, US university students are faster to judge that the spoken words /klu/ clue and /glu/glue rime than to judge that /kxu/ crew and /glu/ glue rime. They are slower to judge that /tum/ tomb and /bam/ bomb don't rime than to judge that/xum/room and /bam/ bomb don't rime (Donnenwerth-Nolan, Tanenhaus, \& Seidenberg, 1981; Seidenberg \& Tanenhaus, 1979).

Literate people's performance in the auditory lexical decision task, which requires them to decide as quickly as possible whether a spoken form is a word of their language, and which is often used to study the perception of spoken words, can be influenced by orthography. Consider some studies of French university students that included words like /d $\tilde{\varepsilon} /$ and /dyn/. /d $\tilde{\varepsilon} /$ is a French word, daim, a type of deer. Its rime is spelled <ain» in other words, such as «sain» /s $\tilde{\varepsilon} /$ 'healthy', but «dain» isn't a French word. The rime of /dyn/ 'dune', in contrast, has no possible spelling other than «une». The participants in these studies took somewhat longer to decide that /d $\tilde{\varepsilon} /$ is a word than that /dyn/ is a word, and they occasionally denied that /d $\mathrm{\varepsilon} /$ was a word (Ziegler \& Ferrand 1998; Ziegler, Petrova, \& Ferrand, 2008; see Ventura, Morais, \& Kolinsky, 2007, and Ziegler \& Ferrand, 1998, for similar results with Portuguese and English). Effects of spelling are particularly strong when the alternative spelling is common, as is <ain» is for $/ \tilde{\varepsilon} /$ in French (Ziegler, Ferrand, \& Montant, 2004). Because spellings persist in memory, the spelling of an item that is included in a lexical decision task may affect performance not only on that
item but also on a later item. For example, literate speakers of English are faster to decide that dirt is a word if they heard shirt immediately beforehand than if they heard moon immediately beforehand. Some of this effect is due to the shared sounds-shirt rimes with dirt-but some is due to the shared letters. This is shown by the fact that responses speed up more, under some conditions, when shirt precedes dirt than when hurt precedes dirt (Chéreau, Gaskell, \& Dumay, 2007; see Pattamadilok, Kolinsky, Ventura, Radeau, \& Morais, 2007, for similar studies with French speakers). Effects of spelling have also been found for nonwords in lexical decision tasks. Thus, Australian university students who first hear the nonword /dxid/, which they are likely to spell as «dread», are faster than otherwise expected to decide that dread is a word (Taft, Castles, Davis, Lazendick, \& Nguyen-Hoan, 2008). Hearing $/ \int$ xid/ doesn't speed lexical decisions to shred because the spellings that people mentally generate for / Jrid/, namely «shread» and «shreed», don’t match <shred». Supporting the idea that such effects reflect orthographic knowledge, they aren't found in children who haven't yet learned to read and write (Ventura et al., 2007). Together, these findings suggest that literate people sometimes activate a written form in memory when they hear a spoken form.

People who know the spelling of a word such as lagoon or often may store in memory a phonological form that corresponds closely to the spelling/læ'gun/ and /'oftən/, in these examples-as well as the more typical pronunciation. People may use the spelling pronunciations not only when trying to
 Gaskell, 2012). This means that words' pronunciations sometimes change over time to better match their spellings. This happened with medicine, which was earlier pronounced with two syllables in England but now more commonly with three, and it is happening with often as well.

Although literacy may cause the pronunciations of some words to change so as to more closely match their spellings, mass literacy may slow the overall pace of language change (Zengel, 1962). For example, it has been argued that English pronunciations have changed less over the last 400 or 500 years than they would have if fewer people knew how to read and write (Gelb, 1952). Knowledge of a spelling that represents the phonological form of a word, according to this argument, stabilizes its pronunciation. Words that aren't normally spelled on the basis of their sounds, such as letter names, may thus change more quickly. And sound change may be more rapid for phonological features that aren't represented in writing, including stress in many languages, than for those that are.

Literacy influences the pronunciations of some words, making them more closely fit their spellings, and it can also influence the vocabulary of a language. If people didn't know how to write and read, for instance, /'e'si/ would almost surely not have entered English as a short term for air conditioner. Without writing, similarly, expressions such as T-bone steak and $L$-shaped would not have entered the English language. The orthography of the
surrounding spoken language influences sign languages as well. For example, the American Sign Language sign for 'job' includes the handshapes for $j$ and $b$ in the manual alphabet. In Israeli Sign Language, a sign for 'preferable' was formed by adding the manual alphabet handshape for the first letter of corresponding Hebrew word, עדיף adif, to a previously existing sign for 'better'. Even punctuation appears to influence sign languages, as when the American Sign Language sign for 'question' is shaped like a question mark.

People use the tool that spelling provides in order to learn and remember new words. When a spelling is difficult or misleading, therefore, people may have difficulty retrieving a newly learned pronunciation (Rastle, McCormick Bayliss, \& Davis, 2011). Even when people don't see the spelling of a new word, they may use an imagined one. Supporting this idea, US 8-year-olds learned novel phonological forms more easily when they were encouraged to spell the items in their minds and use the spellings to aid their memory than when they repeated the nonwords an additional time (Ehri \& Wilce, 1979). In other studies, illiterate adults had difficulty repeating novel phonological forms, at least those that were relatively long (Castro-Caldas, Petersson, Reis, Stone-Elander, \& Ingvar, 1998; Loureiro et al., 2004; Reis \& Castro-Caldas, 1997). These difficulties may arise, in part, because illiterate people can't generate spellings to help them remember phonological forms. Provided that children know how to read, showing them spellings of words helps them to remember the words' meanings as well as their pronunciations (Ricketts, Bishop, \& Nation, 2009; Rosenthal \& Ehri, 2008). This probably happens because people can devote more attention to the meaning when it is easier to remember the form.

Learning a new dialect of a language involves learning phonological forms that are partly new, and knowledge of spelling may play a role here as well. Consider North American speakers of English who include taps and $/ \mathrm{x} / \mathrm{s}$ when pronouncing such words as forty and birdie. If they move to England, they hear forms with / $\mathrm{t} / \mathrm{and} / \mathrm{d} /$ but without $/ \mathrm{x} /$. When the 9 - to 17 -year-olds in one study were exposed to this new dialect, they lost the taps more rapidly than they lost the $/ \mathrm{I} / \mathrm{s}$ (Chambers, 1992). This difference may arise, in part, because elimination of tapping yields pronunciations that agree with spellings whereas elimination of $/ \mathrm{x} /$ yields forms that disagree.

In some writing systems that are basically alphabetic, spellings may reflect morphology as well as phonology. Users of such systems may use information in spellings to guide decisions about morphology. For example, speakers of English may learn that intonation/mntə'ne $2 \mathrm{~m} /$ is related to tone /ton/ based in part on the spelling. Those who don't learn to read and write may not appreciate the link between such words (Scholes, 1993). Orthographic knowledge sometimes promotes incorrect morphological analyses, however. For example, the pronunciation of the word /'savam/ doesn't immediately suggest a connection to the verb /xen/, but its spelling, «sovereign», certainly does. In fact, there is no historical connection between the two words.

In writing systems that set off words by spaces or other marks, children develop a sense of words based on those divisions. The intuitive word of the
literate person is based in part on writing: A word is a unit that is set off by spaces or whatever device is conventional in a particular writing system. The importance of writing in people's ideas about words is evidenced in illiterate adults' poor performance in word segmentation tasks. For example, when asked to repeat the sentence "Le chien noir traverse la forêt" 'the black dog crosses the forest' while pausing between words, a French adult who doesn't know how to read and write may say "le chien noir" as one unit, "traverse" as another, and "la forêt" as a third (Gombert, 1994). Chinese adults who can read and write sometimes disagree about word boundaries in even relatively simple sentences (Hoosain, 1992), probably because written Chinese doesn't mark word boundaries. Disagreements often involve cases that are linguistically unclear, such as whether the grammatical particle de (的) is a separate word. Chinese speakers who learn a language that requires word separation may break its words in unusual ways, as in «fastfood» and «fire ex tinguisher>.

Similarly, the use of periods (or other symbols) at the ends of sentences encourages concepts of sentences that are based on the orthography. Young children may structure speech in terms of phrases rather than sentences, as we discussed in $\int 12.1 .1$, and learning about writing may promote use of sentences.

As mentioned in $\mathbb{1} .6$, modern linguists consider spoken language to be their primary object of study. When analyzing its properties, they attempt to ignore their knowledge of its orthographic form. This can be difficult for them to do, however, just as it is difficult for other literate people. Thus, certain aspects of linguistic theories may be influenced by writing. Some linguists have now questioned their widespread assumption that words are stored in memory as sequences of phonemes, or segments that happen to correspond more or less to the letters of alphabetic writing systems. As Port (2007, p. 144) wrote, "Segments are the basis of our intuitions about speech, but apparently only our intuitions, since our intuitions are strongly biased by the literacy education we have all received."

### 13.2.3 Influences Outside of Language

We have seen that knowledge of writing influences knowledge about language and performance on linguistic tasks. Does it have any effects outside the domain of language? We turn now to studies that suggest that it does.

Given the many hours that literate people spend producing and perceiving fine distinctions among the shapes of writing, they may improve in their ability to deal with other impoverished two-dimensional forms. Some support for this idea comes from a report that literate adults performed better than illiterate adults from similar backgrounds at recognizing and naming black-onwhite line drawings of objects, although they performed just about as well with the corresponding three-dimensional objects (Reis, Petersson, Castro-Caldas, \& Ingvar, 2001).

People usually treat natural objects that are mirror images of one another as instances of the same thing. For example, they don't usually notice if a nature film is accidentally played with left and right reversed. In some writing systems, however, children must learn to count as different shapes that differ only in left-right orientation and must decide which of two familiar shapes to produce in each case. Users of the Latin alphabet must mind their $<\mathrm{p}\rangle \mathrm{s}$ and $<q>s$, users of Korean hangeul must distinguish between $\vdash / \mathrm{a} /$ and $\dagger / \Lambda /$, and users of Japanese must distinguish between the logograms $\lambda$ 'enter' and人'person', the handwritten forms of which are mirror images. This isn't necessary for users of certain other scripts. For example, Tamil doesn't contain any symbols that differ only in left-right orientation. Correspondingly, experienced users of the Latin and Japanese scripts tend to judge novel line drawings that are mirror images of one another as different. People who can't read and write, and people who read and write in Tamil, are more likely to judge them as the same (Danziger \& Pederson, 1998; Kolinsky et al., 2011; Pederson, 2003). These people perceive the difference between forms that differ only in left-right orientation (Kolinsky, Morais, \& Verhaeghe, 1994), but they don't consider it important for categorization. These results suggest that learning that shapes that differ only in orientation count as different in the case of letters has some influences outside the domain of writing.

Writing and reading involve moving the hand and the eye in a particular direction, and those experiences may carry over to other tasks. In the absence of other information, people from the United States appear to anticipate that objects will move from left to right, the direction in which they write. They may remember objects as being slightly further along the implied path than they really are, and they may show more stable and regular eye movements when objects move from left to right than when they move in the opposite direction (Halpern \& Kelly, 1993; Newman, Lamb, \& Civil, 1986; Spalek \& Hammad, 2004, 2005). Under some conditions, too, people who read and write from left to right detect a target more quickly when it is at what is for them the typical beginning position, on their left, than when it isn't (Bramão et al., 2007). Egyptians and Iraqis, who write from right to left, show the opposite effects in some of these tasks (Newman et al., 1986; Spalek \& Hammad, 2005).

Because people sometimes think about abstract concepts in concrete terms, their experience of writing from left to right may lead them to directionality biases in more abstract thought. For example, people sometimes think about time in terms of space. People in countries such as the United States and Spain, who write from left to right, tend to associate the past with left and the future with right (Emmorey, 2001; Santiago, Lupiáñez, Pérez, \& Funes, 2007; Tversky, Kugelmass, \& Winter, 1991; Weger \& Pratt, 2008). For example, when asked to place stickers on a piece of paper to represent times of the day, Americans tend to put morning on the left, noon in the middle, and evening on the right. Israelis, who write from right to left, show the opposite pattern (Fuhrman \& Boroditsky, 2010; Tversky et al., 1991). People from countries in which writing goes from left to right tend to think of the number line as
starting on the left and increasing in magnitude to the right, whereas those who write from right to left tend to have the opposite view (Dehaene, Bossini, \& Giraux, 1993; Shaki, Fischer, \& Petrusic, 2009).

Directionality biases pervade a culture, and children can learn about them through other avenues than writing. For example, Palestinian children can observe that people in their culture usually count sets of objects from right to left (Shaki, Fischer, \& Göbel, 2012), and this may encourage the idea that numbers increase in magnitude from right to left. Such an inference may be strengthened by children's experience with the right-to-left direction of Arabic writing. Supporting the view that experience with a writing system makes a contribution, directionality biases are weak or nonexistent in illiterate adults (Bramão et al., 2007; Shaki et al., 2012).

### 13.2.4 Summary of Writing's Influences

Learning about a writing system allows one to use that writing system, but it has some broader influences as well. Some of these influences are important in everyday life, as when mentally spelling a new word helps someone to remember it, or when writing down an address allows one to avoid the trouble of memorizing it. Other effects are of little practical importance for most people. For example, it doesn't usually matter whether a person thinks of /sin/sing as having three sounds or four or whether flew comes to mind as a rime for drew more rapidly than clue does. Such things do matter for linguists and poets and, of particular importance here, for teachers. In the next section, which deals with the teaching of orthography, we consider some of the implications for teachers.

### 13.3 Instruction About Orthography

Given that children need a level of fluency with letter formation, spelling, and punctuation in order to write effectively, how can they best achieve it? According to the discovery view of learning ( $(\mathbb{1} .3 .1)$, which is instantiated in the domain of literacy as whole language, children discover what they need to know as they look at writing, read for meaning, and write themselves. Instruction that focuses on isolated words and letters is unnecessary, even harmful (Goodman, 2005). The research that we have reviewed in this book supports the idea that children learn some things about their writing system without explicit teaching. For example, children learn about some of the salient visual characteristics of writing starting at an early age, and they implicitly learn about some of the patterns that relate sounds to spellings. Children learn these things, in part, by applying their statistical learning skills to writing. But children aren't limited to implicit statistical learning. Direct instruction and guidance ( $\$ 1.3 .2$ ) speed the learning of orthography, as of other complex systems. In the sections that follow, we offer some guidelines about direct instruction that follow from the research and theory we have discussed in this book.

### 13.3.1 Teach Patterns

We have seen that children use multiple patterns in learning about writing, including information about specific words and general patterns that go beyond specific instances. Some of these general patterns involve the outer form of writing and others pertain to its inner form, or how it symbolizes language. The research we have reviewed shows that children pick up some patterns implicitly, even when the patterns aren't explicitly taught. However, this process can be slow and incomplete. Direct instruction can speed the process.

One way to teach patterns is to point them out to learners. For example, children can be told about the properties that hold for all members of a category; for example, about the properties of all letter shapes in the $\langle\mathrm{C}\rangle$ category. Another way to teach patterns is to help children to induce the patterns. This can be done by exposing children to carefully chosen instances and guiding them to appropriate generalizations. For example, children can be shown different examples of «C» and «G〉 or can produce examples themselves and can be helped to see that «G〉 contains a short horizontal line that «C» lacks. Children benefit not only from abstract statements about patterns but also from practice with examples. Children who are taught a rule about the doubling of final consonants of stems when adding suffixes such as «ing», for example, can practice with words that fit the conditions for the rule, such as «hit>, and words that don't fit the conditions of the rule, such as <heat.

Traditional methods of spelling instruction that focus on rote memorization teach instances but not patterns. Children who receive such teaching have extensive practice with specific words; for example, memorizing a list of words each week. However, the words in each list aren't chosen to exemplify a pattern. Phonics instruction teaches children some of the patterns that relate phonemes to phonograms in alphabetic writing systems, and it works better than approaches that don't include direct instruction about these patterns (Ehri, Nunes, Stahl, \& Willows, 2001). However, conventional phonics instruction is based on the idea that spelling involves unconditioned links between phonemes and phonograms. In fact, as we have seen, some of the links are conditioned on neighboring phonemes or letters. Moreover, a number of writing systems that are basically alphabetic sometimes depart from simple sound-to-spelling rules to spell morphemes in a consistent manner. Phonics instruction promotes the idea that spelling is meant to symbolize the sounds of speech in a simple manner, and this idea isn't correct for some writing systems.

Instructional materials that are designed to convey more complex patterns relating phonemes and phonograms exist, but they have some limitations. For example, a spelling textbook may have children spell a list of words with different spellings of $/ \mathrm{u}$ / but may provide no guidance on which options are most common and when different choices are appropriate (Carreker, 2005). As another example, a number of spelling programs designed for older children don't teach them to identify morphemes within words and use these as guides to spelling (Mullock, 2012).

### 13.3.2 Include Activities That Focus Attention on Writing Itself

Human attention is limited. When reading, children usually pay more attention to words' meanings than to their forms. As a result, they may not develop a lasting memory for spellings. One way to increase the amount that children learn and remember about spelling is to focus their attention on individual words and their components. When children's attention is on these matters, they will be able to deploy their statistical learning skills more effectively and will benefit more from direct instruction, too.

Whereas whole-language advocates maintain that working with isolated words and letters is harmful, impeding children's understanding that the goal of writing is to communicate meaning, research shows that such activities are beneficial. Consider several studies that compared children's memory for the spellings of words that were presented in isolation and in meaningful texts. In one study, US 7 -year-olds practiced reading words like rows and witch, reading each word orally 16 times over the course of several days of training (Ehri \& K. T. Roberts, 1979). In one training condition, each word was presented on a separate card. After the child read the word, with help from the experimenter if needed, the experimenter used the word in a sentence. In another condition, children saw sentences in which the critical words were underlined. Children read the sentences, the experimenter helping them if needed. The children in both conditions were told to pay attention to the letters in the words' spellings and also to think about their meanings. Memory for the words' spellings appeared to be better in the group that had practiced reading the words in isolation than in the group that had practiced reading them in context. Similar results have been reported in several other studies (Dixon \& Kaminska, 2007; Ehri \& Wilce, 1980; but see Nation, Angell, \& Castles, 2007).

Another way to increase attention to spelling is to have children spell words rather than read them. Children and adults who see a word and then reproduce it by writing it by hand, typing it on a computer, forming it from letter tiles, or saying the letter names aloud tend to remember the word's spelling better than those who simply read the word (Bosman \& de Groot, 1992; Bosman \& van Leerdam, 1993; Dixon \& Kaminska, 2007; Jacoby \& Hollingshead, 1990; Van Doorn-van Eijsden, 1984). This is true even when the same amount of time is devoted to reproduction and to reading (Shahar-Yames \& Share, 2008). Because reading a word, even in isolation, doesn't force one to attend to all of the letters within it, reading may not be the most effective way to learn about spelling.

The study of words can be a content area, just like the study of mammals or the study of arithmetic (Invernizzi et al., 1994). In learning about words, as in learning about science, children want to know why things are the way they are. Just as there is a reason that a bat is a mammal, even though it flies like a bird, so there are reasons why words are spelled as they are. In orthography, as in other domains, children can learn about the reasons. Just as generating arguments for why $3 \times 4$ gives the same result as $4 \times 3$ helps children to understand mathematics, so generating reasons about why photo is spelled
with «ph» helps children to understand orthography. Activities involving isolated words and their components can involve words and morphemes that aren't already familiar to students in their oral form as well as those that are. That is, spelling instruction can be integrated with vocabulary learning. This is particularly important for a language like English, where certain important aspects of spelling require knowledge of sophisticated vocabulary, including words that come from Latin and Greek. Without exposure to such vocabulary, children's knowledge about the writing system of their language will necessarily be incomplete. Children find interest and meaning in the study of words themselves, not only in the use of words to communicate with others. Contrary to the suggestion of whole-language advocates, the study of words is not intrinsically boring or meaningless.

Although some classroom time should be spent on individual words, it is important that students also write and read connected texts. During these activities, it is sometimes appropriate to draw attention to spelling. Consider some studies in which university students were asked to silently read and comprehend passages that contained novel personal and place names (Ormrod, 1986a, 1986b). Students who expected a later test on the spellings of the novel words did better on the spelling test than students who didn't expect a test, but the former group performed no worse in a comprehension test. In another set of studies, teenagers and young adults silently read passages containing words that were difficult to spell (Gilbert, 1934, 1935). The students were told to read the passages with a view toward answering questions on their content. They weren't told that their spelling would be tested. Some of the students had taken a spelling test that included the difficult words from the passages just before reading the passages. Other students had taken this spelling pretest several weeks earlier. The students who had taken the spelling pretest immediately beforehand did better on the final spelling test than the other students. The pretest apparently drew the students' attention to their difficulty in spelling words like moccasin and misogyny, encouraging them to pay special attention to these spellings when they read the passage. Pronouncing new or difficult words aloud while reading a text also promotes attention to spelling. This, in turn, improves students' memory for the words' spellings (Rosenthal \& Ehri, 2011).

### 13.3.3 Provide Feedback After Errors

Children strive to follow the conventions of their society, in orthography as in other areas. When they are writing, however, and especially when they are writing connected texts, they will make mistakes. Some teachers who adopt a whole-language approach provide little or no feedback when this happens. They believe that students will be discouraged if explicitly told about their errors. Over time, they think, students will notice when their spellings differ from conventional ones and will change their spellings to match the conventional ones.

Research shows, however, that children and adults sometimes overlook spelling errors that they or others have made. Even when they can detect and
correct a particular error when their attention is drawn to it, they may miss the error in a meaningful text (Figueredo \& Varnhagen, 2004; Plumb, Butterfield, Hacker, \& Dunlosky, 1994; Supramaniam, 1983). A misspelling that is a word tends to be harder to detect than one that isn't (Daneman \& Stainton, 1993), and a misspelling that looks similar to the correct spelling tends to be harder to detect than one that is less similar (Shimomura \& Yokosawa, 1995). Students benefit from instruction in proofreading and from practice in doing so (Personke \& Knight, 1967).

As we have seen throughout this book, corrective feedback is helpful in learning to write words, as in other areas of learning. This doesn't mean, however, that teachers should point out and correct every orthographic error that their students make. In some situations, as in the first draft of a story, it is appropriate to emphasize the expression of ideas and to downplay correctness. Spelling and punctuation can become a focus of attention later, when the piece is revised. Another approach is to provide feedback on some but not all of a student's errors. Teachers did this in one condition of a study that was carried out with Dutch children around 8 years of age. In this condition, they marked mistakes only on words which, it was judged, the student should have known given his or her level of spelling skill. In another condition of the study, teachers marked all mistakes (van Oudenhoven, Siero, Veen, \& Withag, 1983). There was some evidence that the poorer spellers showed more improvement in the former condition than the latter condition.

It needn't be teachers who detect and correct students' mistakes. Students can check and correct their own answers on a spelling test, using a teacher-provided list. This procedure seems to be beneficial (Alvarado-Gomez \& Belfiore, 2000), in part because it forces students to be active rather than passive. Students can also work in pairs or small groups and correct one another's errors. This approach can work well when carefully structured and monitored (Greenwood et al., 1984; Sideridis et al., 1997). Because children must detect and correct their own errors outside the classroom, practice in doing so can be helpful.

Spell-checkers can also help in detecting and correcting errors. However, as mentioned in $\S 1.2 .1$, they aren't a panacea. They often miss errors that are real words. Moreover, in what has been dubbed the Google effect, people often show poor memory for information that they believe to be readily available via an external tool (Sparrow, Liu, \& Wegner, 2011), in this case spellings that are made available by spell-checkers. Supporting this idea, US 9- to 11-year-olds who used a spell-checker to detect and correct misspellings that were planted in a story did no better on an immediately following spelling test for these words than students who didn't use a spell-checker (Jinkerson \& Baggett, 1993). Reading a word doesn't ensure memory for its spelling, as discussed earlier, and reading a word and clicking on it while using a spell-checker doesn't help much, either. Teachers can use spell-checkers to select frequently misspelled words for further study (McClurg \& Kasakow, 1989), but use of spell-checkers doesn't replace further study.

### 13.3.4 Don't Assume Too Much

Children in literate societies know a number of things about writing before formal literacy instruction begins. For example, as discussed in chapter 5 , they have a general idea about what writing looks like. But there are many things that young children don't know. For example, they often have difficulty classifying and analyzing speech at the level that is required for writing. Learning a writing system teaches children about their language, and teachers shouldn't overestimate the linguistic knowledge of children who don't yet know a writing system.

Teachers may overestimate not only children's linguistic knowledge but also their ability to generalize. As one example, practice in reading words doesn't show full transfer to spelling them. As another example, practice with isolated sound-to-spelling correspondences may not transfer to correct spelling of the sounds when they occur in clusters. It is best to teach students what one wants them to know and do rather than relying on them to generalize. Some teachers conclude that systematic instruction in spelling isn't beneficial because students don't always use their knowledge of words practiced during formal instruction in their own writing. Many other things compete for attention when students are composing, though. Students need to continue practice with individual words until the task of spelling them has become easy and automatic. They need to be shown how what they have learned in studying words can be applied in their writing.

Teachers sometimes assume that students know how to study effectively and will make the effort to do so. That isn't always true. Children and adults often overestimate what they know, in spelling (Adams \& Adams, 1960; Tidyman, 1924) as in other areas. People who think that they already know something will make little effort to improve. They may not seek out external aids, such as spell-checkers or dictionaries, and they may not use such aids when they are available-for example, not looking at lists of words that are displayed for their benefit on a wall of their classroom. Overconfident people may even actively reject suggestions from external sources, as when a child who typed "Brittnay Spears" into a search engine and was informed that results for "Britney Spears" were included insisted on her original incorrect spelling by clicking the option "Show only Brittnay Spears" (Duarte Torres \& Weber, 2011). Yet another concern is that overconfident people may use easy study techniques rather than ones that are harder but that yield better long-term results.

### 13.3.5 Teach Teachers as Well as Children

Traditionally, the main qualification for teaching children to read and write was the ability to read and write oneself. This is still true in some parts of the world. The importance of knowledge about physics for a physics teacher is widely appreciated, as is the importance of knowledge about history for a history teacher. Less well known is the importance of knowledge about language and writing systems for teachers of reading and writing. Prospective teachers
need systematic opportunities to acquire this knowledge, and these opportunities aren't always provided to them.

As we have seen, literate people tend to dissect language along the lines laid out by their writing system. Teachers who think about sounds in line with their spellings, as many do (Cunningham, Perry, Stanovich, \& Stanovich, 2004; Moats, 1994), may have difficulty interpreting some of their students' misspellings and responding in appropriate ways. For example, a teacher who doesn't appreciate the logic behind a child's use of $\langle j\rangle$ in <jres〉 for dress may ask the child to listen carefully to the word, not realizing that the child has already listened carefully. Teachers and textbook writers who have difficulty thinking about sounds as distinct from spellings may also choose poor examples for instruction. For example, a teacher may use egg as an example of a word that contains the «e» spelling of $/ \varepsilon /$ even if her students pronounce this word with /e/. A teacher may assume that children can easily derive the so-called short pronunciations of English vowels from the long ones, not knowing that this isn't easily done on a phonological basis. The writer of a spelling textbook may choose reply as an example of a word that contains $/ \mathrm{i} /$, even though this word is normally pronounced with /ə/ (Mullock, 2012).

Well-practiced material seems so easy to experts that they may not appreciate its difficulty for beginners. For example, those who are highly familiar with the spellings of do, pretty, and what, as teachers are, may judge these spellings to be to rather predictable (Spear-Swerling \& Brucker, 2003, 2004). They are well aware that that «fome> would be an odd spelling of /fəm/, but they are less aware that «come», which looks so familiar to them, is oddly spelled (Spear-Swerling, 2000, cited in Spear-Swerling \& Brucker, 2003). Teachers' knowledge of orthography is thus a double-edged sword. It can make it hard for them to appreciate the difficulties that children experience.

One potential way to improve children's learning of orthography is to improve teachers' knowledge about language and writing and their ability to apply this knowledge to instruction. Several studies show that teaching teachers in this way boosts their knowledge (Bos, Mather, Narr, \& Babur, 1999; McCutchen et al., 2002; Spear-Swerling \& Brucker, 2003, 2004). In some studies (Bos et al., 1999; McCutchen et al., 2002), although not all (Spear-Swerling \& Brucker, 2004), it also boosts the spelling performance of their students.

### 13.3.6 It's Just Orthography

Spelling, handwriting, and punctuation are important, but they are just part of writing. A piece of writing with poor content and poor organization is a poor piece of writing, even if letter formation, spelling, and punctuation are perfect. A piece of writing that contains a few spelling errors or punctuation errors may communicate very well. Before children have mastered the writing system of their language, it is worthwhile to spend a little time on orthography each
school day. This is particularly true given that, as mentioned in $\sqrt{ } 3.4$, spaced practice (several short sessions) tends to yield better long-term results than massed practice (one long session of the same total amount of time). However, spending too much time on spelling and punctuation could cause students and teachers to undervalue the many other skills that are required for reading and would take away from other important school subjects.

### 13.4 Assessing Children's Spelling

A better understanding of spelling development can help not only in designing spelling instruction but also in designing spelling tests. Good spelling tests are needed to gauge how instruction is working and how individual children are progressing. Standardized tests that are designed to assess children's academic achievement often include subtests that assess spelling, and other standardized tests focus specifically on spelling. In these tests, children may be asked to identify incorrectly spelled words, to choose the correct spelling of a word from among several choices, or, most commonly, to spell dictated words or sentences.

Standardized tests that involve spelling to dictation are usually scored on a binary basis: A word is either correct or incorrect. Younger children, however, might not spell any words correctly on even the simplest spelling test. Older children produce some correct spellings, but binary scoring doesn't consider the quality of their errors. As we have seen throughout this book, children's spelling errors provide valuable information about their knowledge and skills. To capture this knowledge, spelling tests could give partial credit for spellings that include some correct or plausible elements. For example, a child who spells cat as «c〉 may be credited with a more advanced production than one who spells it as <f>, a child who spells cat <ask> may receive some credit on the grounds that «k> sometimes spells $/ \mathrm{k} /$, and a child who spells dress as $\langle\mathrm{j}\rangle$ may receive some credit on the grounds that $/ \mathrm{d} /$, although never conventionally spelled as $\langle j\rangle$, is pronounced similarly to $/ \overline{d_{3}} /$ when it comes before $/ \mathrm{x} /$. A child who spells cat as 〈leb> might even receive a higher score than a child who spells it as «bbb> on the grounds that the former child seems to know that letters don't normally repeat within a word.

Scoring systems that give partial credit for plausible errors have potential for classroom use, although so far they have been used mainly for research purposes (e.g., Caravolas, Hulme, \& Snowling, 2001). Such scoring is time consuming and liable to error if done by hand, to the point that research assistants who are asked to score a large number of spellings in this way have been known to mutiny. Fortunately, computers are fast and good at following rules in a consistent manner. Several computerized systems of scoring spelling errors have been developed, some of which are proprietary software (e.g., Masterson, Apel, \& Wasowicz, 2009) and others of which are freely available. Our tool, Ponto (Kessler, 2009), falls in the latter category. It scores spellings
using string-edit distance, a technique that determines how many letters must be corrected in order to turn the child's spelling into a correct spelling. It can also score spellings by determining how many sounds the child has spelled with plausible phonograms. Ponto assumes that all sound-to-phonogram correspondences are unconditioned, which makes it particularly useful for evaluating beginning spellers. Unconditioned correspondences are also very easy for users of the tool to specify, so they can enter sets of correspondences tailored to specific languages or specific purposes. Past users have also donated correspondence tables that they have developed for a variety of languages and dialects.

### 13.5 Differences Between Children

This book has focused on what is common to all children learning the writing system of a particular society. The preceding discussion of spelling tests, however, serves as a reminder that some children learn to use their writing system more quickly than others. We didn't review the research on how and why children differ in the central chapters of the book. However, the research that we did review, together with the theoretical framework that we developed, is helpful in thinking about individual differences. As we have stressed, humans are not born knowing about writing. They must learn even its most basic aspects, such as the fact that writing is different from drawing and the fact that units of writing stand for units of language. Learning to use a writing system draws on many skills and abilities, including statistical learning, memory, attention, symbolic thinking, and knowledge of and about language. Strengths or weaknesses in any of these areas can have consequences for learning to use orthography. Discussions of why some children are better than others at learning to spell in alphabetic writing systems have often focused on individual differences in their knowledge about one aspect of language: that spoken words can be broken into phonemes (Ehri et al., 2001). Important as this is, it isn't the whole story. Researchers and educators need to look at a broader range of skills and abilities if they wish to understand why some children learn their writing system more rapidly than others. Perhaps more importantly, they need to study the kinds of instruction that help both stronger and weaker learners to succeed.

### 13.6 Final Words

Nearly everyone in a modern society reads, and more and more people are writing. They e-mail, they text, they write messages using social media. The ability to read is widely agreed to be important in modern societies, and the ability to write is becoming increasingly important. Still, schools usually stress reading more than writing. Researchers, too, have carried out more studies of
how children learn to read than of how they learn to spell. Given the importance of spelling and writing, and given that learning to spell benefits reading as well as writing, a change is called for. If this book increases researchers' and educators' focus on how children learn to produce writing, our goal in writing it will have been achieved.

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