CHAPTER

11 SCHOOLING AND COGNITIVE DEVELOPMENT

IN THIS CHAPTER

Eight-year-old Nicholas was reading a book with his grandmother, who was impressed at how well he was reading and told the young boy so. "It's a trick, Grandma," he said, almost conspiratorially. "I'm not really reading. I just see the word and I know it." Nicholas no longer had to sound out words to "know" them, and to him, this wasn't reading, it was a trick. Nicholas had "broken the code." He was no longer learning to read but was on his way to reading to learn.

Reading is perhaps the single most important technological skill in postindustrial cultures. Children learn to read using universal cognitive skills, but it is unheard of for an unschooled child from an illiterate culture to learn to read. Humans did not evolve to read. Unlike language, reading is rarely acquired spontaneously.

Reading is understandably classified in educational circles as a language skill, but it is a very different language skill, acquired in a very different way, from a child's native tongue. Although all neurologically typical children learn to be proficient speakers of their native language, not all learn to be proficient readers, even with instruction.

If reading is the number one technological skill in modern society, mathematical abilities must come in second. Verbal and quantitative skills constitute the two major subtests of the Scholastic Assessment Test (SAT), the Graduate Record Exam (GRE), and even most IQ tests (see Gardner, 1983). Although there is more to verbal and quantitative abilities than reading and mathematics, these are the core abilities. Unlike with reading, basic mathematical skills can be acquired without formal schooling. However, beginning in preschool, children in postindustrial societies receive instruction in simple number concepts and arithmetic, and math constitutes one of the primary subject areas in schools.

In this chapter, we review the development of reading and mathematical abilities. Individual, gender, and cultural differences in these topics have been of great interest to educators and the public at large, and we devote considerable space to these issues. In the latter part of the chapter we look at several issues directly related to cognitive development and schooling. We selected these issues from the many topics we could have included in this chapter primarily because we believe they are related to issues that we have already dealt with in this book or will deal with in the final two chapters: First, how does the effect of schooling influence cognitive development in comparison with the effect of age? Second, what is the effect of schooling on IQ? We conclude the chapter with a brief section on a new way of thinking of the relation between schooling and cognitive development: *evolutionary educational psychology*.

DEVELOPMENT OF READING SKILLS

Overview of Learning to Read

Learning to read involves acquiring a set of skills that are built on preceding skills. Jeanne Chall (1979) proposed five stages in the development of proficient reading, ranging from the prereading skills of the preschool child to the highly skilled reading of the adult.

Stages of Learning to Read

In Stage 0, covering the years before a child enters first grade, children must master the prerequisites of reading, most notably learning to discriminate the letters of the alphabet. By the time children enter school, many can already "read" some words, such as *Pepsi*, *McDonald's*, *Pizza Hut*, and perhaps their own names. Many also now recognize some of the letters in their name, especially the first letter (Trieman et al., 2007). Their ability to recognize these symbols, flashed at them from the television and seen repeatedly on the roadside or the dinner table, indicates that they can tell the difference between patterns of letters, even if they are unable to sound out the words. Children's knowledge of letters and single words is generally better than it was several generations ago, partly because of the influence of children's television shows such as *Sesame Street*.

Stage 1 covers children's first year of formal reading instruction. In kindergarten or first grade, children learn phonological recoding skills, used to translate written symbols into sounds and thus words. This is followed in the second and third grades by Stage 2, in which children learn to read fluently. By the end of the third grade, most children have mastered the letter-to-sound correspondence and can read many words and simple sentences. But reading is effortful for these children, in that the process of identifying individual words requires so much of their limited mental resources that they often do not comprehend much of what they read. They are still concentrating on what individual sets of letters mean and are not very skilled at putting the words together to discern the broader meaning of the text.

The change from learning to read to reading to learn begins in Stage 3, usually spanning Grades 4 through 8. Children can now more readily acquire information from written material, and this is reflected by the school curriculum. Children in these grades are expected to learn from the books they read. If children have not mastered the "how to's" of reading by fourth grade, progress in school can be difficult. Stage 4, beginning in the high school years, reflects truly proficient reading, with adolescents becoming increasingly able to comprehend a variety of written material and to draw inferences from what they read.

Not surprisingly, like many other things, children become better readers the more they read. This results in an interesting phenomenon called the **Matthew effect**, in which the difference between good and poor readers increases over time (Stanovich, 1986). The name comes from the New Testament's Book of Matthew, which makes the observation (basically) that the rich get rich and the poor get poorer. ("For to everyone who has, more shall be given, and he will have an abundance; but from the one who does not have, even what he does have shall be taken away," Matthew 25:29, New American Standard Version.) Good readers, because they enjoy and are relatively good at reading, read more and thus become increasingly proficient at reading, whereas poor readers, who are less skilled and enjoy it less, read less and, although they may be improving in an absolute sense, find themselves falling further behind their more skilled peers. And developing reading proficiency early has important implications for later reading and achievement. In fact, the results of a 2011 longitudinal study of nearly 4,000 students revealed that children who had not become proficient readers by the end of third grade were 4 times more likely to drop out of school than proficient readers, with this rate being nearly 6 times greater for children who failed to master basic reading skills by the end of the third grade (Hernandez, 2011).

Emergent Literacy

Although most children learn to read in school, most learn *about* reading in the home. They learn that arbitrary written symbols correspond to spoken language and convey meaning. They learn that writing is used to communicate with others, as a memory reminder (writing down a phone number to call later), and for pleasure. In the United States and many other literate cultures in the world, books are written for the sole purpose of adults to read to children. Parents who share storybooks and picture books with their preschool children are teaching them much about reading and are preparing their children for success in a literate culture. For example, mothers and fathers who read to their children have children with better language, cognitive, and reading abilities (Oliver, Dale, & Plomin, 2005), as do preschoolers who participate in shared reading programs at school (Piasta et al., 2012). Reading child-appropriate picture books to children may be especially important, as such books have a greater diversity of words than is found in conversation with children, providing an important source of vocabulary for preschoolers (Montag, Jones, & Smith, 2015). In fact, the American Academy of Pediatrics (2014) advises that all parents should read age-appropriate books aloud to their children, beginning in infancy, to promote language and preliteracy skills.

Further evidence that reading to young children promotes language and literacy skills is provided by a recent brain-imaging study. John Hutton and his colleagues (2015) imaged the brains of nineteen 3- to 5-year-old children while they listened to age-appropriate stories and related patterns of brain activation to children's history of being read to. Children who were exposed to more language, including being read to, compared to children who were read to less often, showed greater neural activation in the left parietal-temporal-occipital association cortex, an area of the brain associated with language processing, mental imagery, and narrative comprehension. This effect held even after controlling for family income. This result suggests that being read to not only affects the brain while children are hearing a story but also establishes a pattern of neural activation associated with better imagery and understanding, critical in efficient reading.

But most preschool children do not read—not really. They might be able to identify Coca-Cola, Burger King, or Fruit Loops signs when they see them, but this is not really reading. Nevertheless, what children are learning during story times with a parent and in a household where reading is done frequently are skills that set the stage for true reading. The idea that there is a developmental continuum of reading skills, from those of the preschooler to those of the proficient reader, is referred to as **emergent literacy**. According to Grover Whitehurst and Christopher Lonigan (1998) emergent literacy "consists of the skills, knowledge and attitudes that are presumed to be developmental precursors to conventional forms of reading and writing . . . and the environments that support these developments (for example, shared book reading)" (p. 849). Whitehurst and Lonigan (1998) list nine components of emergent literacy:

1. *Language.* Reading is obviously a language skill, and children need to be versatile with their spoken language before they can be expected to read it. However, skilled (and even early) reading requires more than just proficiency with spoken language. Reading does *not* seem to be simply a reflection of spoken language, with children with advanced language skills becoming children with advanced reading skills.
2. *Conventions of print.* Children exposed to reading in the home know the conventions of print. For example, in English, children learn that reading is done left to right, top to bottom, and front to back.
3. *Knowledge of letters.* Knowledge of letters is critical for reading, and most children can recite their ABCs before entering school and can identify individual letters of the alphabet (although some children think *elemeno* is the name of the letter between *k* and *p*).
4. *Linguistic awareness.* Children must learn to identify not only letters but also linguistic units, such as phonemes, syllables, and words. Perhaps the most important set of linguistic abilities for reading deals with phonological processing, or the discrimination and

making sense of the various sounds of a language.

5. *Phoneme-grapheme correspondence.* Once children have figured out how to segment and discriminate the various sounds of a language, they must learn how these sounds correspond to written letters. Most begin this process during the preschool years, with letter knowledge and phonological sensitivity developing simultaneously and reciprocally.
6. *Emergent reading.* Many children pretend to read. They will take a familiar story book and "read" one page after another, often "just like Daddy does," or will take an unfamiliar book and pretend to read, making up a narrative to go along with the pictures on the pages.
7. *Emergent writing.* Similar to pretend reading, children often pretend to write, making squiggles on a page to "write" their name or a story, or stringing together real letters to produce something they think corresponds to a story, a shopping list, or a note to Mom.
8. *Print motivation.* How interested are children in reading and writing? How important is it for them to figure out what the secret code is that permits adults to make sense of a series of marks on a page? Children who are interested in reading and writing are more likely to notice print, ask questions about print, encourage adults to read to them, and spend more time reading once they are able.
9. *Other cognitive skills.* A host of individual cognitive skills, in addition to those associated with language and linguistic awareness, influence a child's reading ability. Various aspects of memory are important, and some of these will be discussed.

Relations between any specific component of emergent literacy and later reading are sometimes difficult to establish. However, it is clear that families that provide the whole package of emergent literacy skills to their children have children who are better readers, both early in school and later, than do families that provide less of the package (Sénéchal & Jo-Anne LeFevre, 2002, 2014; Whitehurst & Lonigan, 1998). This has been confirmed by longitudinal studies that report significant relations between emergent literacy skills assessed during the preschool years and reading ability in elementary school (Lonigan, Burgess, & Anthony, 2000; Storch & Whitehurst, 2002).

As in other aspects of school performance, differences in reading are frequently found as a function of socioeconomic status (SES) (Schwanenflugel & Knapp, 2016). Children from poverty homes are much more likely to encounter reading problems in school than are children from middle-income homes. The point we want to make here is that these SES differences do not begin in school but in the home in the years before children begin formal reading instruction. Parents from lower-SES families are much less likely to read to their children, have fewer books in the house, and generally do not foster the emergent literacy skills that are so important in learning to read. Reading may be a highly technological skill, but its origins are in everyday family interactions.

Does this mean that children's literacy skills are determined before they enter school? No, but their experiences at home do establish a foundation on which school instruction is based. And the quality of home environments tends to be stable. Children who receive intellectual support for literacy early in life can expect similar support later on. (See Chapter 13 for a discussion of the stability of intelligence.) This implies that children from homes in which emergent literacy is *not* fostered will likely not receive the kind of support during the elementary school years that is associated with proficient reading. It also suggests that if the amount or quality of support in the environment (both home and school) changes for the better, so, too, may children's reading abilities (Lonigan et al., 2013; Schwanenflugel et al., 2010). For example, Anne Hargrave and Monique Sénéchal (2000) reported that preschool children with vocabulary skills more than 1 year behind their peers showed significant gains in vocabulary as a result of small-group (eight children per group) shared book reading. More recent research by Christopher Lonigan and his colleagues (2013) similarly reported improvements in letter knowledge or phonological knowledge as a function of small-group reading interventions for groups of low-income children.

Cognitive Development and Reading

There are a number of cognitive abilities related to skilled reading that develop over the preschool and school years (Hulme & Snowling, 2013). Charles Hulme and Margaret Snowling (2013) examined the cognitive processes underlying early reading skills in alphabetic languages, using evidence from (a) comparisons of children with and without reading disabilities, (b) longitudinal studies examining the early cognitive abilities that predict later reading ability, and (c) training studies that look at the effect that instruction in a particular skill has on improvements in children's reading proficiency. They identified three "cognitive foundation" skills for early reading: letter knowledge, phonemic awareness, and rapid automatized naming. We investigate research on each of these skills briefly in the following sections, as well as two other cognitive skills that become important in children's later reading, phonological recoding and working memory.

Letter Knowledge

In the previous section on emergent literacy, we noted letter knowledge is critical for reading. A number of studies have reported a connection between letter knowledge and later reading. For example, several studies have found moderate associations between children's letter knowledge at the beginning of first grade and reading ability at the end of the school year (Lervåg, Bråten, & Hulme, 2009; Muter et al., 2004), whereas other research has shown that preschool children given training in letter knowledge improved their preliteracy skills both immediately following the training and 5 months later (Bowyer-Crane et al., 2008). Hulme and Snowling (2013) proposed that letter knowledge permits children to sound out words on a letter-by-letter basis, as well as establish letter-to-sound (visual-phonological) associations, which permits children to mentally represent a printed word with its pronunciation. Proficient reading does not involve sounding out individual letters but rather recognizing whole words and retrieving meaning directly from long-term memory, but this cannot be done effectively until children master knowledge of individual letters.

Phonemic Awareness

Phonemic awareness is the knowledge that words consist of separable sounds. Such awareness is generally not available to preschool children. In one early study, 4- and 5-year-olds were taught to tap once for each sound in a short word (Liberman et al., 1974). For instance, children would tap twice for *at* and three times for *cat*. Although the children presumably understood the task, their performance was poor, with none of the 4-year-olds (and only a few of the 5-year-olds) performing it accurately. Although this task might seem trivial, it predicts children's early reading achievement quite well (Melby-Lervåg, Lyster, & Hulme, 2012). Other aspects of phonological awareness (such as children's abilities to detect rhymes) also develop slowly during the preschool and early school years and predict reasonably well children's early reading skills (Brunswick, Martin, & Rippon, 2012; Wagner et al., 1997). This is also true in languages other than English (Caravolas et al., 2012), including Chinese, which includes a phonetic component in its characters (McBride-Chang & Wang, 2015).

These findings are only correlational, and perhaps children who read well acquire good phonemic awareness along the way. But there is also evidence of a causal influence of phonemic awareness on reading abilities. For example, some longitudinal studies that measure phonemic awareness well before children learn to read show that children with good phonemic awareness as prereaders become more proficient readers when they start school (Brunswick et al., 2012; Lyytinen et al., 2001). Also, preschool, kindergarten, and first-grade children who receive instruction in phonemic awareness show enhanced early reading ability relative to children not given such instruction (Bowyer-Crane et al., 2008; Cunningham, 1990). Anne Cunningham (1990) states that the results from her training study argue against the idea that phonemic awareness is a consequence of learning to read. Rather, she proposes, as have others (Hulme & Snowling, 2013), phonemic awareness is causally related to reading achievement, even in the early stages of learning to read.

Research has shown that children's sensitivity to rhymes leads to awareness of phonemes, which in turn affects reading and also presumably makes it easier for children to recognize written words that both sound and look alike (for example, *cat* and *hat*) (Bryant et al., 1990). Other research has suggested that it is not children's sensitivity to rhymes, per se, that is the critical component to literacy but rather the ability to segment phonemes (Muter et al., 1998). Valerie Muter and her colleagues tested a group of preschool children (average age, 4 years, 3 months) on rhyming and phonemic segmentation abilities. Tests of rhyming included asking children to identify pictures and then to pick out those that rhyme, and to produce words that rhymed with each of two words (*day* and *bell*). For one test of phonemic segmentation, children were shown a picture of an object (a cat, for instance), the interviewer provided the first two phonemes (*ca*), and children were asked to finish the word (in this case, say *t*). In another test, children were shown a picture and asked to say the word without the first phoneme (for example, "Bus without the /b/ says . . . ," with the correct response being "us"). The researchers reported that reading ability at the end of first grade was significantly related to preschool phonemic segmentation ability but not to rhyming ability.

Rapid Automatized Naming (RAN)

In Chapter 7 we discussed speed of processing with respect to executive functions and working memory. Briefly, we noted that children become faster at processing information with age and that the speed with which they process information is related to how many items they can hold in working memory. The less time it takes children to process a word, for example, the more time they have to work on that word (rehearse it, for instance) before it decays from working memory. With respect to reading, speed of processing has been investigated using **rapid automatized naming (RAN)** tasks. RAN refers to the ability to rapidly name as many familiar items (words, numbers, colors, digits) as possible. Many studies have reported significant relations between RAN and reading fluency for children over a broad age range (Kirby et al., 2010), and between children with and without reading disabilities (Norton & Wolf, 2012), with "faster" children displaying better reading abilities.

George Georgiou and his colleagues (2013) questioned why RAN is related to children's reading fluency. The researchers administered groups of Grade 2 and Grade 6 Greek children a series of speeded tasks and related children's performance to their reading proficiency. Georgiou et al. reported that the RAN tasks that best predicted reading ability were those in which children had to name randomly arranged recurring digits and objects (for example, naming as quickly as possible the digits 2, 4, 5, 7, and 9, presented randomly a total of 10 times each on a computer screen). Georgiou and his associates suggested that the reason RAN and reading ability are so highly correlated is because both require serial processing—processing a known set of items sequentially (words in text for reading and items on a computer screen for RAN)—as well as the articulation of specific names. In other words, speed matters, and children who are faster to articulate series of individual items display greater reading fluency than slower children.

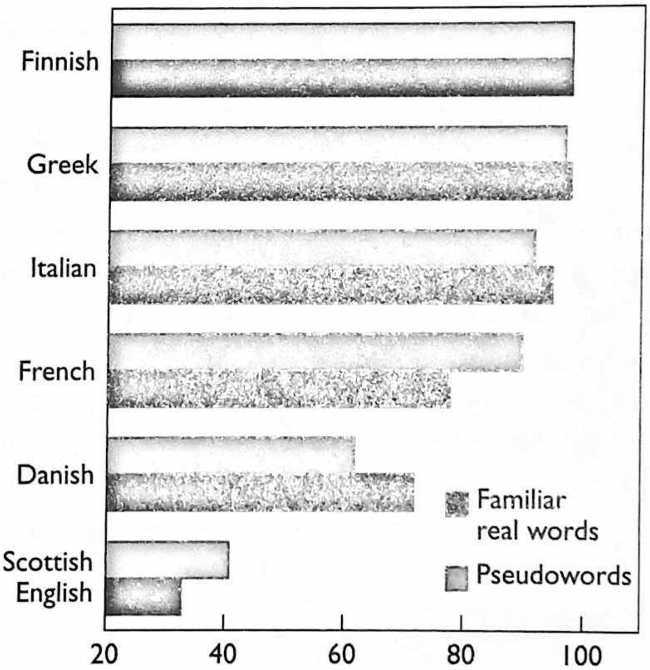
Phonological Recoding

The reason that phonological awareness is such a good predictor of early reading is that early reading generally involves sounding out words. This process of **phonological recoding** is the basis of the majority of reading-instruction programs in the United States today (the *phonics* method). Children are taught the sound of each letter and how to combine these sounds, blending them into words.

The relation between printed and spoken words is referred to as *grapheme-phoneme correspondence*, and how easy it is for children to learn to read is related to how obvious these relationships are in their language. For example, as speakers and readers of English, you are likely aware that the relationship between letters and sounds is often quite variable, and this represents a difficult task for readers. For instance, the playwright George Bernard Shaw commented that, following the rules of English spelling, *ghoti* should be a perfectly acceptable alternative spelling for the word *fish*: *gh* as in *cough*, *o* as in *women*, and *ti* as in *nation* (go ahead, sound it out). English has what is called a *deep orthography*, meaning the spelling system for converting letters into sounds is irregular, with there being multiple ways in which some letter combinations can be sounded out. Other languages, such as Finnish, German, and Italian, have *shallow orthographies*, with there being a close correspondence between letters and their sounds. For example, Italian uses 25 phonemes, and 33 combinations of letters are used to represent these sounds. In contrast, English uses 40 phonemes, but 1,120 different letter combinations are needed to completely represent these sounds. Because of these differences, languages with shallow orthographies such as Spanish and Italian are relatively easy to learn to read, whereas languages with deep orthographies such as English and Danish are more difficult to learn to read.

The relationship between children's reading ability and the degree to which the written language corresponds to the spoken language (that is, the degree to which a language is orthographically regular) is illustrated in Figure 11.1. This figure presents the percentage of children speaking and reading languages with shallow orthographies (Greek, Finish, and Italian) and languages with deep orthographies (French, Danish, and Scottish English) who correctly read familiar real words and pseudowords (Seymour, Aro, & Erskine, 2003; Ziegler & Goswami, 2005). Pseudoword reading requires children to read a sequence of pronounceable letters that do not make up a word (for example, *joak*, *kake* in English). As you can see, performance was nearly perfect for children reading languages with regular (shallow) orthographies but much lower for children reading languages with irregular (deep) orthographies. The effect of the depth of a language's orthography not only influences children's ability to decode nonsense words but is associated with the rate at which children learn to become proficient readers. For example, Philip Seymour and his colleagues (2003) reported that after 1 year of instruction, children learning Dutch, which has a shallow orthography, were able to read an average of 95% of words correctly, whereas English-speaking children achieved only a 34% accuracy.

FIGURE 11.1 Percentage of correct responses of children reading familiar real words and pseudowords for orthographically regular languages (Finish, Greek, and Italian) versus orthographically irregular languages (French, Danish, and Scottish English).

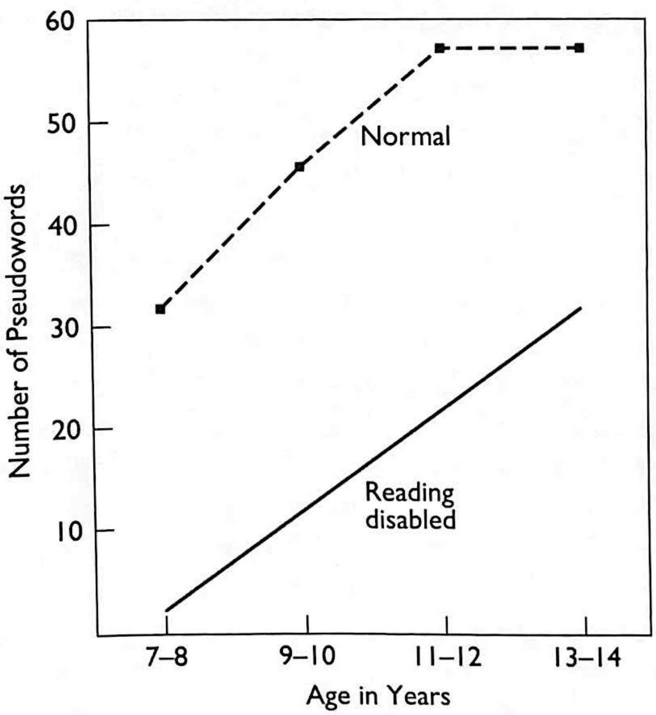


Source: Adapted from data in Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundations of literacy acquisition in European orthographies. *British Journal of Psychology, 94*, 143–174.

The importance of phonological coding to proficient reading can also be seen by looking at children with reading disabilities, often referred to as **dyslexia** (Melby-Lervåg et al., 2012). Children are said to have a reading disability if they have great difficulty in learning to read despite an average intelligence. Stated another way, if a child's reading ability is substantially worse than his or her general intellectual ability would predict, that child is said to have a reading disability, or dyslexia. Perhaps the single best predictor of reading difficulty is phonological processing, including phonological recoding (Melby-Lervåg et al., 2012; S. White et al., 2006). For example, early research by Linda Siegel and her colleagues (Siegel, 1993; Siegel & Ryan, 1988) compared the phonological processing of groups of children with and without reading disabilities ages 7 to 14 years. As one test of phonological processing, children were asked to read pseudowords. As can be seen in Figure 11.2, older children with reading disabilities were better at pseudoword reading than younger disabled readers were, demonstrating that these skills were developing. However, the performance of 13- and 14-year-old children with reading disability was comparable to that of 7- and 8-year-old nondisabled readers, reflecting a significant delay of this skill. Moreover, longitudinal research suggests that phonological-processing abilities remain relatively stable over childhood (Storch & Whitehurst, 2002; Wagner et al., 1997), making early intervention all the more important.

Research using brain-imaging techniques has supported the interpretation that phonological problems are at the core of many reading disabilities (Shaywitz, Mody, & Shaywitz, 2006; Shaywitz et al., 1998). For example, Sally Shaywitz and her colleagues (1998) gave adults with developmental reading disabilities and non–reading disabled adults a series of reading-related tasks that varied in the amount of phonological processing required to perform each task. Brain activation patterns, as measured by functional MRI (see Chapter 2), were observed between the normal and dyslexic readers. Shaywitz and her colleagues reported different brain-wave patterns for the nondisabled and disabled readers, especially when the tasks required substantial phonological processing. Compared with the nondisabled readers, the normal readers showed underactivation in some portions of the brain (mainly posterior regions) and overactivation in others (mainly anterior regions). Underactive parts of the brain included those areas typically associated with phonological processing and cross-modal integration. In reading, cross-modal integration (see the discussion of cross-modal integration in infancy in Chapter 4) involves the translation of symbols in one modality (in this case vision, as in the letters and words on a page) into another modality (in this case audition, as in the sounds of letters and words). Shaywitz and her colleagues (1998) concluded that the patterns of brain activity of dyslexic readers "provide evidence of an imperfectly functioning system for segmenting words into their phonological constituents . . . and adds neurobiological support for previous cognitive/behavioral data pointing to the critical role of phonological analysis and its impairment in dyslexia" (p. 2640).

FIGURE 11.2 Accuracy of pseudoword reading as a function of age for normal and reading-disabled children. The number of pseudowords correctly read increased with age for both groups of children but was higher at each age for the normal children than for the children with reading disability.



Source: Siegel, L. S. (1993). The cognitive basis of dyslexia. In R. Pasnak & M. L. Howe (Eds.), *Emerging themes in cognitive development: Vol. 2. Competencies* (pp. 33–52). New York: Springer-Verlag. Copyright © 1993 Springer-Verlag New York, Inc. Reprinted with permission.

Further evidence for the neurological basis of reading disability comes from a study assessing brain activation patterns of dyslexics in Great Britain, France, and Italy (Paulesu et al., 2001). Eraldo Paulesu and his colleagues reported similar patterns of brain activity (PET) while reading for groups of university-level English-, French-, and Italian-speaking dyslexics. Moreover, all three groups showed deficits in tests of phonological short-term memory, pointing, again, to problems in phonological processing as the basis for dyslexia. But there was an interesting catch in this study. Although dyslexics from the three languages did equally poorly in tests of phonological processing, only the English and French speakers showed problems in reading. The Italian dyslexic group displayed relatively good reading ability. They had been identified as dyslexic based on impaired reading speed and poor phonological processing, true reading difficulties being rare in Italian university-level adults.

Why should this be so? The reason seems to be related to the specific language people speak, and specifically, the relationship between how a language is spoken and how it is written. As noted earlier, the correspondence between spoken and written Italian is quite close, whereas both English and French have deep orthographies.

What this research indicates is that the neurological basis of dyslexia is universal, likely the result of unknown genetic or prenatal anomalies; however, the likelihood that this particular neurological abnormality will adversely affect reading is a function of how closely the written language of one's culture corresponds to the structure of its spoken language. If you recall from Chapter 3 our discussion of the tools of intellectual adaptation a culture provides to its members, the relationship between the structure of one's spoken and written language is another unexpected (at least to us) way in which one's culture influences one's thought.

Working Memory

Efficient reading involves a series of processes, each of which must be integrated with one another for proper comprehension. Individual words must be identified and related to other words in the sentence. One factor that limits children's comprehension is the amount of information they can hold in working memory at any one time. Over 30 years ago, Meredyth Daneman and her colleagues proposed that it is necessary for information to be retained in working memory for as long as possible so that each newly read word in a passage can be integrated with the words and concepts that preceded it. Younger or less-proficient readers have less available mental capacity to store and maintain information in working memory because it is necessary for them to devote considerable capacity to the processes involved in identifying words and comprehension. Daneman and her colleagues showed that listening span, defined as the number of successive short sentences that can be recalled verbatim, correlates significantly with comprehension for people ranging from preschoolers to college students (Daneman & Blennerhassett, 1984; Daneman & Green, 1986).

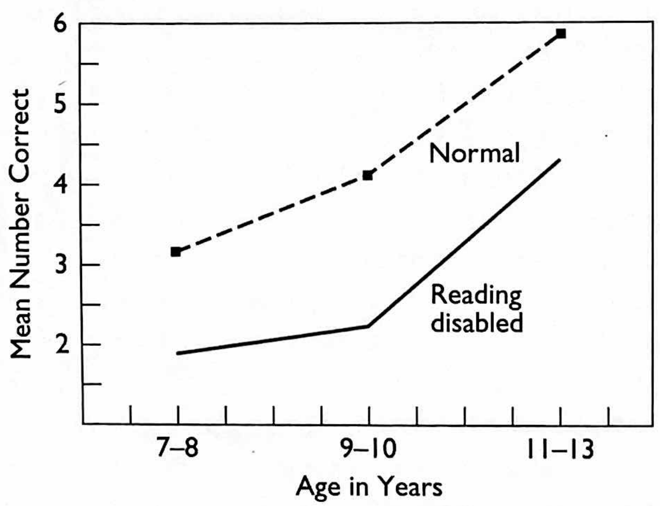
More recent research has clearly shown the relationship between memory span and reading ability for children over a broad age range (Pickering, 2006; S. Wang & Gathercole, 2013). The relationship between working memory and reading comprehension was demonstrated in a longitudinal study that followed children ages 8 to 11 years (Cain, Oakhill, & Bryant, 2004). The researchers reported that individual differences in working memory predicted subsequent levels of reading comprehension independent of children's vocabulary and general reading abilities. Moreover, deficits in working memory have been found to be related to the incidence of reading disabilities (S. E. Gathercole et al., 2006; Swanson & Jerman, 2007). For example, in an early study, Linda Siegel and Ellen Ryan (1989) gave 7- to 13-year-old children with and without reading disabilities a series of incomplete sentences, requiring them to supply the final word of each sentence. Sentences included the following: "In the summer it is very ________," "People go to see monkeys in a ________," "With dinner we sometimes eat bread and ________." After being presented two, three, four, or five such sentences, children were asked to repeat the final words, in order, that they had generated for each sentence (presumably *hot*, *zoo*, and *butter* here). The results of the study are graphed in Figure 11.3. As can be seen, working memory improved with age for both the children with and without reading disabilities, but the children with reading disabilities had shorter memory spans than the normal readers at each age level.

Sex Differences in Reading and Verbal Abilities

STOP Here.

"Female superiority on verbal tasks has been one of the more solidly established generalizations in the field of gender differences," wrote Eleanor Maccoby and Carol Jacklin (1974, p. 75) in introducing their section on gender differences in verbal ability in their seminal book that set the stage for contemporary investigations of sex differences. In reviewing research on sex differences in verbal abilities more than 20 years after the publication of Maccoby and Jacklin's book, Diane Halpern (1997) concluded that females, on average, perform better than males do on "tasks that require rapid access to and use of phonological and semantic information in long-term memory, [and] production and comprehension of complex prose" (p. 1091). The topic of sex differences in verbal ability has continued to be of interest to contemporary researchers, in part because of the importance reading and verbal ability have for education and economic success in modern society.

FIGURE 11.3 Performance on a working-memory task as a function of age for children with and without reading disabilities. Working memory increased with age for both groups of children but was higher at each age for the normal children than for the children with reading disability.



Source: Siegel, L. S. (1993). The cognitive basis of dyslexia. In R. Pasnak & M. L. Howe (Eds.), *Emerging themes in cognitive development: Vol. 2. Competencies* (pp. 33–52). New York: Springer-Verlag. Copyright © 1993 Springer-Verlag New York, Inc. Reprinted with permission.

One technique that has permitted researchers to better evaluate the extent of sex differences in verbal abilities is **meta-analysis**. Meta-analysis provides an estimate of *effect size*, which is expressed in terms of how large the average differences between males and females are across various studies, taking into consideration the overall amount of variability. An effect size of 1.0 would mean that the average male-female difference was one standard deviation in magnitude. If this were for IQ, for example, it would be equivalent to saying that the average difference between the sexes was about 15 points, which would be quite substantial. The statistic of effect size is used because it would be meaningless to compute mean performance across the many different studies, which used different measurements and often assessed different verbal tasks. By using the effect-size statistic, differences in performance among different studies can be meaningfully combined.

The first meta-analysis of verbal sex differences was reported by Janet Hyde (1981), who examined 27 studies of verbal ability included in the original Maccoby and Jacklin (1974) review.