

theories of how people learn or develop or think, today's educational psychology seeks to build domain-specific theories within each subject area. For example, instead of asking domain-general questions such as, "How do people learn?" "How do people develop?" or "How do people think?" we can ask, "How do people learn to solve mathematics problems?" "How do people develop mathematical competence?" or "How do people think mathematically?" By examining cognition in the context of real academic tasks rather than in contrived laboratory tasks, we can develop more realistic theories of how people learn, develop, and think. Although sporadic interest in psychologies of subject matter popped up throughout the 20th century—such as Huey's (1908/1968) *Psychology and Pedagogy of Reading* or Thorndike's (1922) *Psychology of Arithmetic*—the groundbreaking consensus to focus on specific subject domains occurred only within the last 25 years (Mayer, 2004; Shulman & Quinlan, 1996). In the first section of this book, I explore five promising paths to the study of learning in the content areas:

Learning to read fluently (Chapter 2): Students learn how to read printed words.

Learning to read for comprehension (Chapter 3): Students learn how to make sense of printed text.

Learning to write (Chapter 4): Students learn how to produce written essays.

Learning mathematics (Chapter 5): Students learn how to solve mathematics problems in fields such as arithmetic, algebra, and geometry.

Learning science (Chapter 6): Students learn how to explain how scientific systems work in fields such as physical, biological, and earth sciences.

In addition there is much promising research on learning in other subject areas such as history (Carretero & Voss, 1994; Leinhardt, Beck, & Stainton, 1994; Wineburg, 1996).

The second promising contribution of educational psychology is a focus on instruction for meaningful learning. No single instructional method is guaranteed to promote meaningful learning. Although researchers and teachers have discovered several roads that can lead to learning for transfer, each must be crafted to fit the needs of the learner, the requirements of the learning task, and the personal skills of the teacher. In the second section of this book, I explore eight promising paths to promoting meaningful learning.

Teaching by giving productive feedback (Chapter 7): Teachers critique student performance.

Teaching by providing concreteness, activity, and familiarity (Chapter 8): Teachers allow guided exploration.

Teaching by explaining examples (Chapter 9): Teachers allow students to learn from examples of how to accomplish academic tasks.

Teaching by guiding cognitive processes during learning (Chapter 10): Teachers encourage students to engage in appropriate cognitive processing as they learn.

Teaching by fostering learning strategies (Chapter 11): Teachers help students learn how to learn.

Teaching by fostering problem-solving strategies (Chapter 12): Teachers provide help as students learn how to think.

Teaching by creating cognitive apprenticeship in classrooms (Chapter 13): Teachers allow students to learn by participating with others in academic tasks.

Teaching by priming students' motivation to learn (Chapter 14): Teachers try to motivate students to work harder.

Educational psychology has a unique and central role to play within the fields of education and psychology. To education, educational psychology can contribute a theoretical account of how the human mind works in academic settings including how students learn, remember, and use academic knowledge. By constructing cognitive theories of academic learning, educational psychologists enable the development of more effective methods of instruction. In short, educational psychology offers an alternative to education's unproductive proclivity for basing instructional practice on undocumented facts. To psychology, educational psychology can contribute an ecologically valid context for generating and testing cognitive theories. By challenging psychologists to develop theories that can account for academic learning, educational psychologists ensure the authenticity of cognitive theories. In short, educational psychology offers an alternative to psychology's unproductive record of developing precise theories of artificial learning tasks.



Chapter Summary

The example of the Wild Boy of Aveyron raises issues concerning the role of education in human development. A boy raised in the wild without human guidance failed to reach his full potential as a human being. This example suggests that natural experience—everyday interactions with the environment—must be supplemented by manipulated experience in the form of instructional sequences designed by teachers. The example is important because it was one of the first to emphasize a learner-centered view of education.

Educational psychology is a branch of psychology concerned with understanding how the instructional environment and the characteristics of the learner interact to produce cognitive growth in the learner. Instruction refers to manipulations intended to foster learning. Learning refers to a relatively permanent change in a person's knowledge based on experience. Thorndike and Dewey both recognized that the central theme in education is an externally manipulated change in the learner. The definition of educational psychology requires a distinction between the behaviorist approach, which focuses solely on external conditions of learning such as instructional manipulations and outcome performance; the cognitive approach, which adds internal conditions of learning such as learner characteristics, learning processes, and learning outcomes; and the contextualist approach, which also considers the social and cultural context of learning.

The history of the relationship between psychology and education includes three phases: (1) a one-way street in which educators were supposed to apply what psychologists created, (2) a dead-end street in which psychology and education went their separate ways, and (3) a two-way street in which psychology and education mutually enrich one another. In addition, the history of psychology and education includes the progression of three metaphors: learning as response strengthening, learning as knowledge acquisition, and learning as knowledge construction.

In order to help students learn, it is useful to understand how people learn. A cognitive theory of learning is based on three learning principles from cognitive science: dual channels principle, limited capacity principle, and active processing principle. The learner's learning system consists of three memory stores—sensory memory, working memory, and long-term memory—and three kinds of cognitive processes: selecting, organizing, and integrating. The learner-centered approach is based on the idea that instruction helps

learners bring about change in their knowledge. Five kinds of knowledge are facts, concepts, procedures, strategies, and beliefs.

There are six factors in the process of teaching and learning: instructional manipulations, learning context, learner characteristics, learning processes, learning outcome, and outcome performance. Instructional manipulations may result in no learning, rote learning, or meaningful learning. Meaningful learning requires that the learner pay attention, that the learner possess appropriate prerequisite knowledge, and that the learner actively organize and integrate the new information with existing knowledge. Instruction should be sensitive to the three forms of cognitive load—intrinsic cognitive load, extraneous cognitive load, and germane cognitive load.

Transfer is an important educational goal. Three theories of transfer are specific, general, and mixed.

Evidence-based practice is the idea that educational practice should be guided by scientific evidence. The remainder of this book examines what researchers have discovered about how students learn various academic tasks and how to promote meaningful learning.

SUGGESTED READINGS

- Alexander, P. A., & Winne, P. H. (2006). *Handbook of research in educational psychology*, Second edition. Mahwah, NJ: Erlbaum. (Systematically presents everything you ever wanted to know about educational psychology.)
- Bransford, J. D., Brown, A. L., & Cocking, R. (Eds.). (1999). *How people learn*. Washington, DC: National Academy Press. (Summarizes research on how people learn.)
- Dewey, J. (1938). *Experience and education*. New York: Collier. (Provides a dose of Dewey's "child-centered" educational philosophy.)
- Shavelson, R. J., & Towne, L. (Eds.). (2002). *Scientific research in education*. Washington, DC: National Academy Press. (Describes how to conduct educational research.)
- Zimmerman, B. J., & Schunk, D. H. (2003). *Educational psychology: A century of contributions*. Mahwah, NJ: Erlbaum. (Provides engaging biographies of 16 premier educational psychologists including Thorndike, Dewey, and James.)

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Section I Learning

The first section of this book examines learning in the content areas—namely, reading, writing, mathematics, and science. In particular, I focus on the cognitive processes needed to accomplish basic academic tasks such as reading a word, comprehending a passage, writing an essay, solving a story problem, or explaining a scientific phenomenon. In Chapter 2, I explore the cognitive processes involved in reading words, including recognizing and producing the 42 sound units of English, converting printed words into spoken sounds accurately, converting printed words into spoken sounds fluently, and recognizing the meaning of printed words. In Chapter 3, I explore the cognitive processes involved in comprehending passages, which include using your existing knowledge, analyzing the organization of the passage, making necessary inferences, and keeping track of your level of understanding. In



Chapter 4, I explore the cognitive processes involved in writing an essay, including planning what you want to say, putting words on paper, and revising what you have

written. In Chapter 5, I explore the cognitive processes involved in solving a story problem, which include translating each sentence into a mental representation, integrating the information into a coherent mental representation of the problem situation, devising a step-by-step solution plan, and carrying out the plan. In Chapter 6, I

explore the cognitive processes involved in explaining a scientific phenomenon, which include recognizing that your current theory is flawed, inventing a new theory, and using the new theory to make predictions. Importantly, in each chapter I also examine research on how to teach students to engage in the cognitive processes needed to carry out these basic academic tasks.

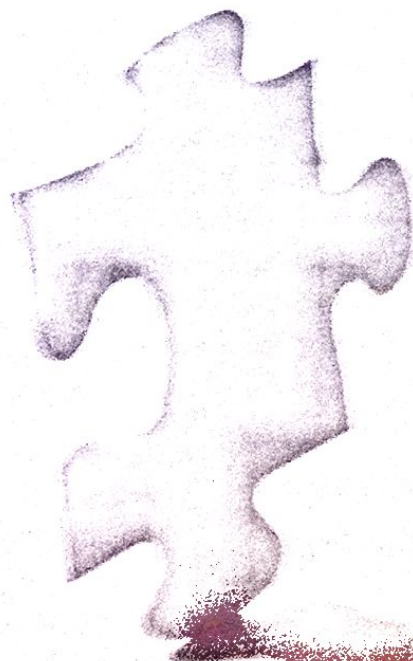
2

Learning to Read Fluently

Chapter Outline

The Problem of Reading a Word
Recognizing Phonemes
Decoding Words
Decoding Words Fluently
Accessing Word Meaning
Chapter Summary

Learning to read is a fundamental national goal, because academic and economic success often build on the ability to read words quickly and effortlessly (National Reading Panel, 2000). Unfortunately, one out of five adults in the United States is functionally illiterate, and these people account for 75% of the unemployed and 33% of the prison population (Adams, 1990). This chapter is concerned with early reading instruction. In particular, this chapter focuses on four processes involved in learning to read: recognizing the sound units that compose words, decoding these symbols on the page into pronounced words, decoding words rapidly and with expression, and accessing the meaning of each word in long-term memory. In this chapter, I explore research and instructional implications for each of these topics.





The Problem of Reading a Word

Let's consider the task of reading words from a printed page, as you are doing now. How much time do you think that it takes you to read a typical word? To answer this question, we can ask people to read a paragraph on a computer screen, while a computer measure where their eyes fixate (Carpenter & Just, 1981; McConkie & Rayner, 1975). Although it might feel like your eyes glide in a smooth and continuous movement across the page as you read, they actually jump along in a series of fixations. Research conducted during the past 25 years (Crowder & Wagner, 1992; Rayner & Sereno, 1994; Reichle, Pollatsek, Fisher, & Rayner, 1998) provides clear and consistent evidence of the following aspects of eye movements during reading.

Fixation duration: A reader's eyes typically focus on a point in the text for an average of 100 to 250 milliseconds.

Fixation span: The reader focuses on six to eight letter positions (i.e., one medium-sized word or two small words) on each fixation.

Second duration: It takes about 15 to 30 milliseconds for the reader's eyes to jump to another point in the text, a time so fast that you are not aware of the movement.

Thus, the answer to our simple question is that competent adult readers can read a word in a fraction of a second, usually less than one quarter of a second. The act of reading a word may seem so rapid and so automatic that it could not possibly involve much cognitive processing. However, in this introduction, I will try to convince you that the seemingly simple act of reading a word may indeed involve many cognitive processes.

WHAT COGNITIVE PROCESSES ARE INVOLVED IN READING A WORD?

First, say aloud each of the four words in the first row of Figure 2-1. Based on the sounds in the words, circle the word that lacks a sound that is present in the other three words. Now, follow this same procedure for each set of four words. Suppose the words are read to you, so you do not have to look at any printed letters. This would be a test of **phonological awareness**, that is, the ability to recognize that words are made up of component sounds. For example, in the first row of Figure 2-1 the sound unit (or **phoneme**) common to three

FIGURE 2-1

Which word does not belong?

For each set of four words, circle the word that does not belong:

1. song long pain wrong

2. hit pit fan sit

3. boat treat bank chunk

4. shoe light ship sheet

FIGURE 2-2

Can you pronounce these words?

caz	saif	cyght	hought	frish	beight
fign	shud	phrend	blud	nal	

words is /ng/, so the correct answer is "pain." The other answers are "fan," "treat," and "light." When Bradley and Bryant (1978) used a similar task to evaluate students' ability to recognize sound units in words, they found that good readers were successful but that poor readers often were not. It thus appears that an important process in reading is recognizing the separate phonemes that make up words as separate sound units.

Second, try to pronounce each "word" in Figure 2-2. If you are like most adult readers, you used a variety of pronunciation strategies and made errors on about one tenth of the words (Baron, 1977). Some possible strategies are sounding out the letters and blending them together, finding a real word that rhymes with the nonsense word, and pronouncing a real word that is similar to the nonsense word. This word-pronunciation task highlights an aspect of reading referred to as *decoding*, which is the process of translating printed symbols into sounds.

Now, let's try another task related to reading. Read aloud the passage in Figure 2-3 over and over again until you can do it with proper expression and rhythm, and without stumbling over any of the words. Pretend you want to read like an experienced newscaster, who can read aloud with expression and without error. How many times did you have to repeat this passage, which was borrowed from a study by Carpenter and Just (1981)? The students in a study by Samuels needed six or seven repetitions before being able to read age-appropriate passages fluently (Samuels, 1979). This is an example of *decoding fluency*, that is, reading aloud rapidly and with expression and rhythm.

Let's try one more reading task, using Figure 2-4. You will need a pencil and a watch with a second hand (to record your starting time and ending time for this task). Remembering to record your times, circle each word in Figure 2-4 that is a member of the category "animal." If you are like most readers, you were able to accomplish this task without too much difficulty. For those of you who like to keep score, the list contains seven animals, and it takes school children about 1 second per word to make decisions like the ones

FIGURE 2-3 Can you read like a newscaster?

Repeat this passage until you can read aloud with proper expression and rhythm, and without stumbling or hesitation:

Radioisotopes have long been valuable tools in scientific and medical research. Now, however, four nonradioactive isotopes are being produced.

They are called "icons"—four isotopes of carbon, oxygen, nitrogen, and sulfur.

FIGURE 2-4 Circle each animal word.

house	rabbit	tree	shoe	horse	table
mountain	elephant	dog	lamp	bed	shirt
zebra	belt	deer	cloud	basket	mouse

Adapted from Baron (1977).

you made (Perfetti & Lesgold, 1979). This word-recognition task requires decoding as well as the process known as *meaning accessing*. Meaning accessing refers to searching long-term memory for the meaning of a word.

The four tasks you just tried represent four kinds of processes in reading words: recognizing phonemes, decoding words, decoding words fluently, and accessing meaning. In this chapter, a brief historical and theoretical overview are presented, followed by an examination of each of these four kinds of processes.

WHAT IS READING?

Any serious discussion of reading must confront the problem that reading means different things to different people. For example, reading researchers make a fundamental distinction between *learning to read* and *reading to learn* (Adams, 1990; Chall, 1979; Singer, 1981; Weaver & Resnick, 1979). Learning to read involves learning how to translate printed words into another form, such as pronouncing and understanding words. Developing automaticity in this translation process is a dominant focus of reading instruction in Grades K–3. Although many students may achieve reading fluency by the third grade, other children may complete junior high school without mastering basic reading skills (Singer, 1981). The present chapter deals with this phase of reading, which can be called *reading fluency*.

Reading to learn involves the use of reading as a tool for gaining specific knowledge in some subject domain. This activity includes comprehension and evaluation of entire passages. The acquisition of specific knowledge from reading is a dominant focus of reading instruction in Grade 4 and thereafter. Chapter 3 examines techniques for improving students' success in extracting useful knowledge from text, which is called *reading comprehension*.

A HISTORY OF READING RESEARCH

In the early days of educational psychology, the question of how people learn to read was a fundamental research issue. In his classic book *The Psychology and Pedagogy of Reading*, Huey (1908/1968) summarized the importance of understanding the reading process:

And so to completely analyze what we do when we read would almost be the acme of a psychologist's achievement, for it would be to describe very many of the most intricate workings of the human mind, as well as to unravel the tangled story of the most remarkable specific performance that civilization has learned in all its history. (p. 6)

Unfortunately, the early enthusiasm for experimental research on reading did not find a comfortable home in the psychology of the early 1900s. The behaviorist movement, which swept across the scene during the first half of the 20th century, was not consistent with the study of underlying cognitive processes in reading. As Kollers points out in his introduction to a reissued version of Huey's book in 1968, "remarkably little empirical information has been added to what Huey knew" (p. xiv). The rebirth of cognitive psychology in the 1960s brought with it a renewed interest in the psychological study of

reading. During the past decades, many models have been proposed to describe the processes by which people understand written language. Although a review of all the proposed models is beyond the scope of this book, most include the basic cognitive processes of recognizing phonemes, decoding words, decoding words fluently, and accessing word meaning.



Recognizing Phonemes

WHAT IS PHONOLOGICAL AWARENESS?

Phonological awareness refers to knowledge of the sound units (phonemes) used in a language, including the ability to hear and produce separate phonemes. Following initial work by Mattingly (1972), Wagner and Torgesen (1987) define phonological awareness as “awareness of and access to the phonology of one’s language” (p. 192). Similarly, Blachman (2000, p. 483) defines phonological awareness as “awareness of the phonological segments in speech,” and Ehri et al. (2001) refer to the “ability to focus on and manipulate phonemes in spoken words” (p.253). Some researchers use the term *phonemic awareness* to refer to awareness of the smallest sound units (phonemes) and *phonological awareness* to refer to awareness of all sound units (including phonemes, syllables, and words), but for our purposes I use the terms interchangeably to refer to awareness of phonemes.

Phonological awareness involves knowing that words are composed of sound units and that sound units can be combined to form words. For example, the spoken word “hat” consists of three phonemes: /h/, /a/, and /t/. Phonological awareness refers to (1) the process of breaking a spoken word into its sound units—such as being able to discriminate the sounds /h/, /a/, and /t/ when the word “hat” is spoken—and (2) the process of producing and blending sound units to form spoken words—such as being able to produce and blend these three sounds when one wants to say the word “hat.”

If you looked at a spectrogram showing the speech stream for a sentence such as “The cat in the hat is back,” you would not see a series of neatly separated sound units. Instead, you would see continuous waves representing acoustic energy. Acoustic speech entering our ears comes as a continuous flow. The apparent segmentation that we hear is based on our cognitive processing, rather than on the acoustic properties of the utterance. The ability to segment a continuous flow into discrete sound units requires learning by the listener.

Standard American English contains approximately 42 basic sound units (i.e., “phonemes”), as summarized in Table 2-1, although regional differences in pronunciation and dialect can create more units. Interestingly, there are more than 26 phonemes in English because some letters can produce more than one sound. For example, “c” can be hard as in “cat” or soft as in “cent.” Phonological awareness of English does not focus on awareness of the relation between letters and sounds (that skill is covered in the next section on decoding), but rather consists of representing these sound units in long-term memory.