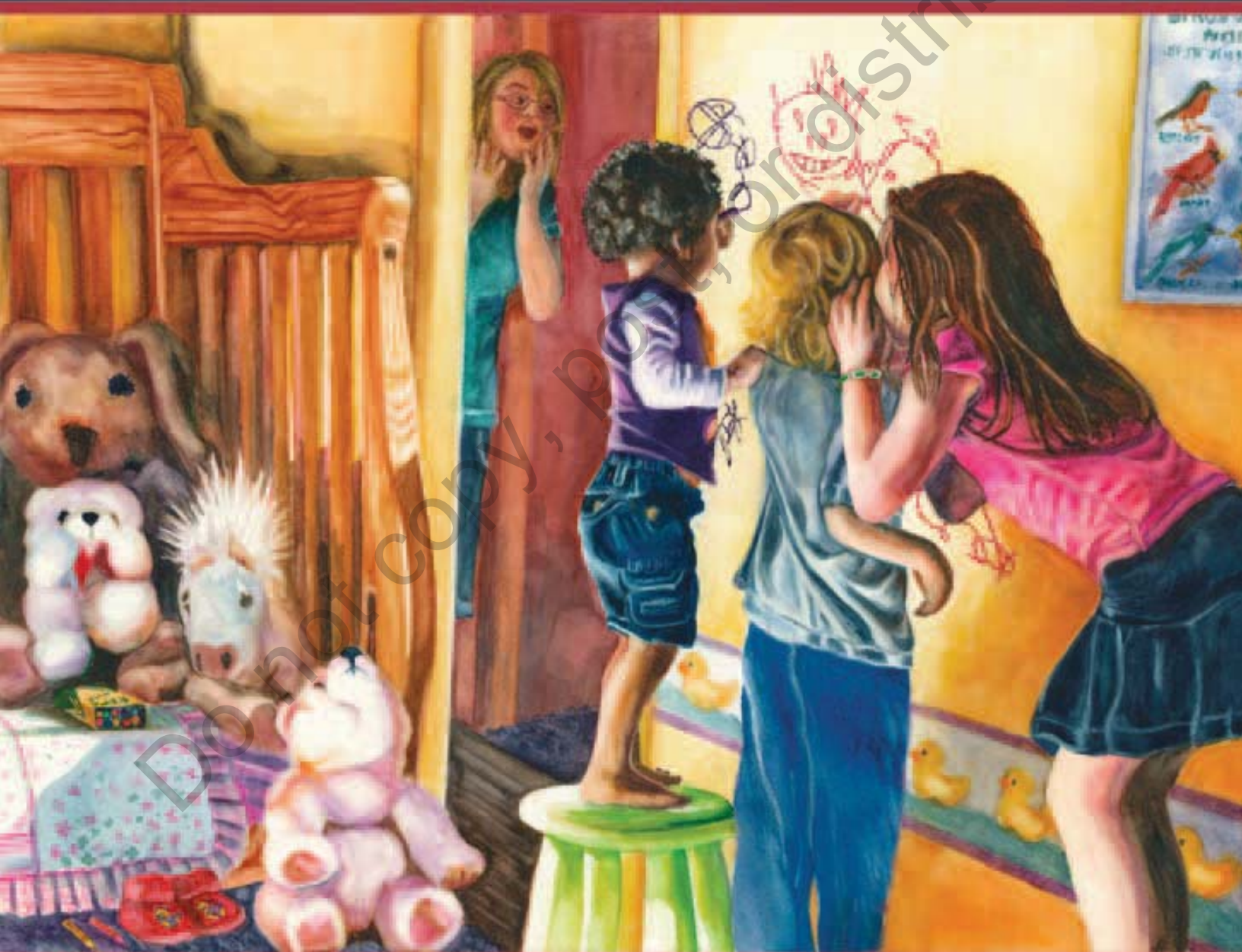


SECOND EDITION

Cognitive Development

Infancy Through Adolescence



Kathleen M. Galotti

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CHAPTER 3

OTHER FRAMEWORKS RELEVANT TO COGNITIVE DEVELOPMENT

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THEORIES AND FRAMEWORKS ●

The theories of Vygotsky and Piaget that we covered in Chapter 2 were written specifically about cognitive development; thus, their relevance is already established. However, theirs are not the only theories or frameworks that have relevance for cognitive developmental phenomena. Here, we'll consider two other theories, ones developed in related areas of psychology such as cognitive psychology and animal learning, that have explanations for phenomena of cognitive development. We will then consider two other approaches—which are not theories per se but rather frameworks that have bearing on certain developmental phenomena as well.

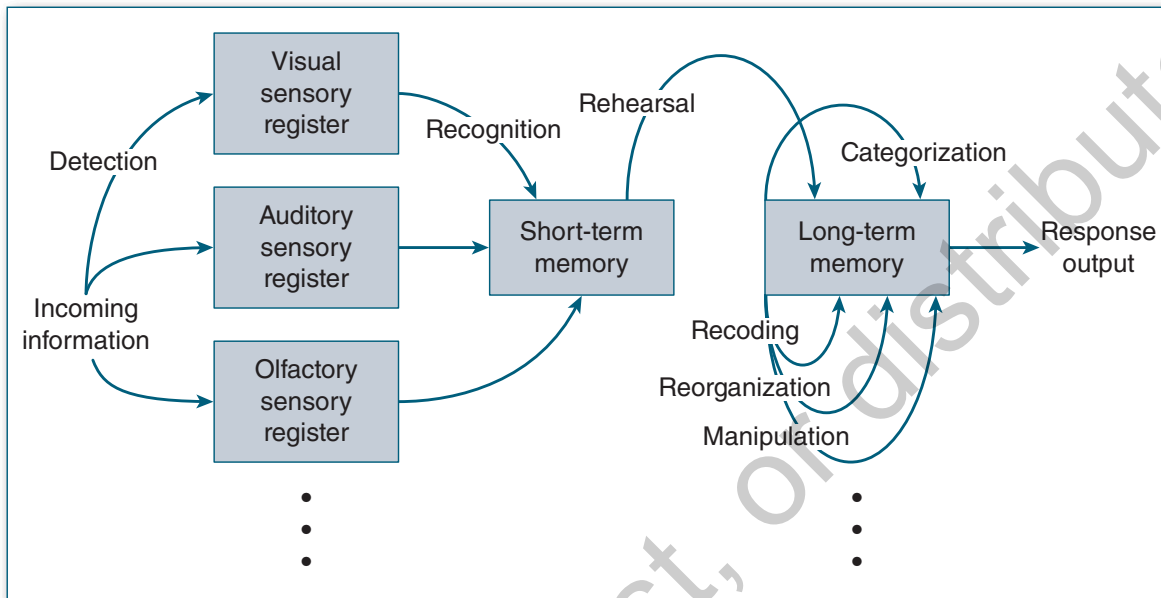
Throughout chapters to come, we'll be considering a number of specific empirical studies of cognitive development. In order to evaluate these studies, we will need to review some basic principles of research methods. The second half of this chapter will provide a brief presentation of the major approaches cognitive developmental psychologists use to investigate phenomena.

Information-Processing Theory

Information-processing theory provides a description of human cognition that borrows heavily from computer architecture. This approach was developed in the 1960s as the computer revolution was in full swing. Although many psychologists contributed to developing the main ideas, the two who are most often credited with the initial formulation of the information-processing approach are Richard Atkinson and Richard Shiffrin (1968).

Figure 3.1 depicts a general model of information processing. It contains boxes that represent *memory stores*—structures that hold onto information for some period of time—and arrows to depict processes that operate on the information. Those of you with computer programming experience might be reminded of a flowchart, an apt analogy for this kind of model. The general notion of an information-processing model of cognition is that information flows through a system, being stored and transformed in various places as different processes take place. A goal of the information-processing framework, then, is to specify precisely what these storage places and processes are—how many; when, where, and how they operate; and most important for our purposes, how they change with development.

Information-processing theorists view memory as storage and are concerned with both the number of different stores (memory systems) an individual has and how these stores operate. Notice that this view opens the door to a number of different possibilities for developmental change. Infants could develop more and more varied kinds of storage, for example.

Figure 3.1 A typical information-processing model

SOURCE: Galotti (2014, p. 16).

Or they could become more efficient in the way they use their memory stores. Or the capacity of the memory storage could grow with development. Or the duration with which information can be stored could grow with development. Or some combination of some or all of these possibilities could provide the best explanation of memory development.

Let's begin by taking a look at proposals for different kinds of memory stores. Cognitive psychologists have long debated whether different kinds of memories exist. Some information-processing theorists have argued that the evidence supports only one central memory store, with different kinds of processing done on the information at the time of encoding (Craik & Lockhart, 1972). Other information-processing theorists believe there are different memory systems that operate according to different principles, use different processes, and/or store different kinds of information. Many such distinctions have been proposed.

In the early days of cognitive psychology, working memory was called **short-term memory (STM)** to distinguish it from **long-term memory (LTM)**. This distinction actually went back to psychologist William James (1890/1983), who used the terms *primary* and *secondary memory* to draw this distinction. Long-term memory was thought to have

several characteristics quite different from those of short-term memory. Here are a few examples: STM was thought to have strong capacity limitations, while LTM was thought to have either unlimited or at least vast amounts of capacity; information in STM was thought to last up to about a minute, while information once transferred to LTM was thought to last either indefinitely or at least for a very long time.

Another distinction commonly proposed is that between **recognition memory** and **recall memory**. Both are **retrieval** processes—that is, processes by which information that has been stored in memory are brought back to conscious awareness (Galotti, 2014). The difference is in whether or not the individual must fully re-create the stored information, in the case of recall, or whether the individual must simply show awareness that the presented information has been previously encountered. A familiar example might be a test—the essay questions would be instantiations of recall questions, while most multiple-choice questions allow the test taker to recognize the correct answer. Most of the time, recognition processes are thought to be less cognitively taxing than recall processes, although exceptions have been noted (Klatzky, 1980). We'll look at research suggesting that, even in infancy, both kinds of memory exist.

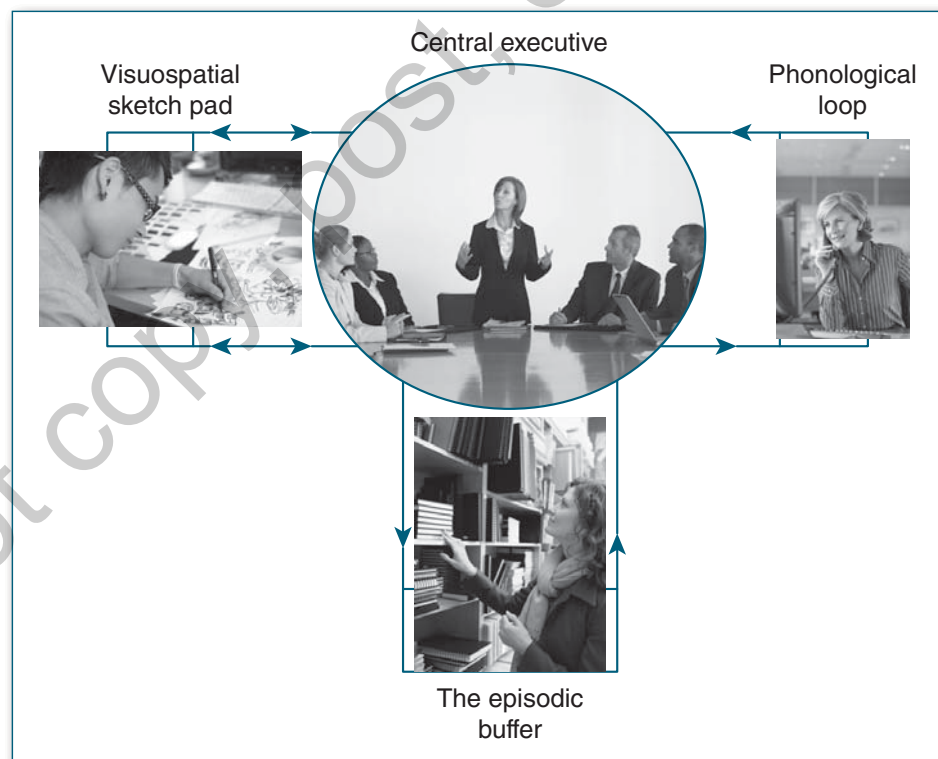
Endel Tulving (1972) proposed a different categorization of memory stores: one that contains information about general knowledge and one that contains memory traces of information from one's personal experience. **Episodic memory** is thought to contain your memories that trace to a specific event, such as your recollection of your third birthday party or the time you visited Disneyland—in other words, memories for events that you remember occurring at a particular time and place (even if you don't remember exactly what that time and place was). **Semantic memory**, in contrast, contains your general knowledge—for example, that Harry Potter is a fictional wizard, that George Washington was the first president of the United States, or that kids usually carry backpacks to elementary school. Finally, many psychologists distinguish between **implicit memory**—that is, memory that one isn't explicitly aware of having but that affects one's current behavior—and **explicit memory**, in which the person shows clear evidence of conscious or deliberate recollection or recall of previously experienced events (Roediger, 1990).

Most of the proposals for different memory stores concerned long-term memory, and these proposals are not necessarily mutually exclusive. In contrast, theorizing about what was called short-term memory has coalesced around a single proposal originally offered and later amended by cognitive psychologist Alan Baddeley (1986, 1996, 2007) on working memory.

Baddeley conceived of working memory as being a limited-capacity “workspace” that can be divided between storage and control processing. He

initially conceived of it as consisting of three components. The first is the **central executive**. This component directs the flow of information, choosing which information will be processed, when it will be processed, and how it will be processed. In this sense, the central executive is thought to function more as an attentional system than a memory store (Baddeley, 1990), meaning that rather than dealing with the storage and retrieval of information, the central executive deals with the way resources are allocated to cognitive tasks. The central executive is also thought to coordinate information coming from the current environment with the retrieval of information about the past in order to let people use this information to select options or form strategies. You can think of the central executive as the manager—it decides what tasks you should attend to and how much effort you should devote to each.

Figure 3.2 Baddeley's (2000) model of working memory



SOURCE: Galotti (2014, p. 111). *Photo credits:* Visuospatial sketch pad, Ciaran Griffin/Photodisc/Thinkstock; Central executive, Nick White/Digital Vision/Thinkstock; Phonological loop, Getty Images/Photodisc/Thinkstock; The episodic buffer, Michael Blann/Digital Vision/Thinkstock.

The two other components of Baddeley's model are concerned with the storage and temporary maintenance of information: the **phonological loop**, used to carry out subvocal rehearsal to maintain verbal material, and the **visuospatial sketch pad**, used to maintain visual material through visualization. Researchers think the phonological loop plays an important role in such tasks as learning to read, comprehending language, and acquiring a vocabulary. It's the storage place for auditory material—it holds onto the sounds of what you've just heard or maybe just read. The visuospatial sketch pad involves the creation and use of mental images. If you imagine a mental map of your campus, for example, you are making use of the visuospatial sketch pad.

In 2000, Baddeley revised his original model of working memory to include a fourth component—the **episodic buffer**. It is thought to be another temporary storage system, but one that interacts with both the phonological loop and the visuospatial sketch pad, as well as with LTM. It, too, is controlled by the central executive and is used to integrate information across different modalities and to facilitate the transfer of information into and from LTM. Figure 3.2 presents a depiction of Baddeley's working memory proposal.

One source of cognitive development that the information-processing theory proposes is an increase in capacity of these stores. Younger children have been shown to have lower working memory spans than older children (Cowan, 2010)—that is, the number of unrelated pieces of information they can hold in their mind is much lower than the number for adults. Having a larger memory capacity would allow children to work on harder tasks and to process more information.

A second proposed cause of development is increased processing efficiency in transferring information from one store to another. Processing speed is a possible factor explaining some aspects of cognitive change in children. We know that as children mature, more of the **neurons** in their brains become myelinated (Couperus & Nelson, 2006). **Myelin** is a fatty substance that wraps around the long axons of *neurons*, the basic cells that transmit information throughout the body and the brain. The function of myelin is to speed the nerve impulses. Essentially, this means that as a child matures, he can process more information in the same amount of time or the same amount of information in less time. Thus, older children are able to respond to stimuli and to process information about the stimuli more quickly than younger children.

Attentional control surely also contributes to cognitive development. We will see in the chapters to come that **attention spans** increase as children age. An individual's attention span governs the amount of time she can focus on a task; having a longer attention span would in turn make possible an

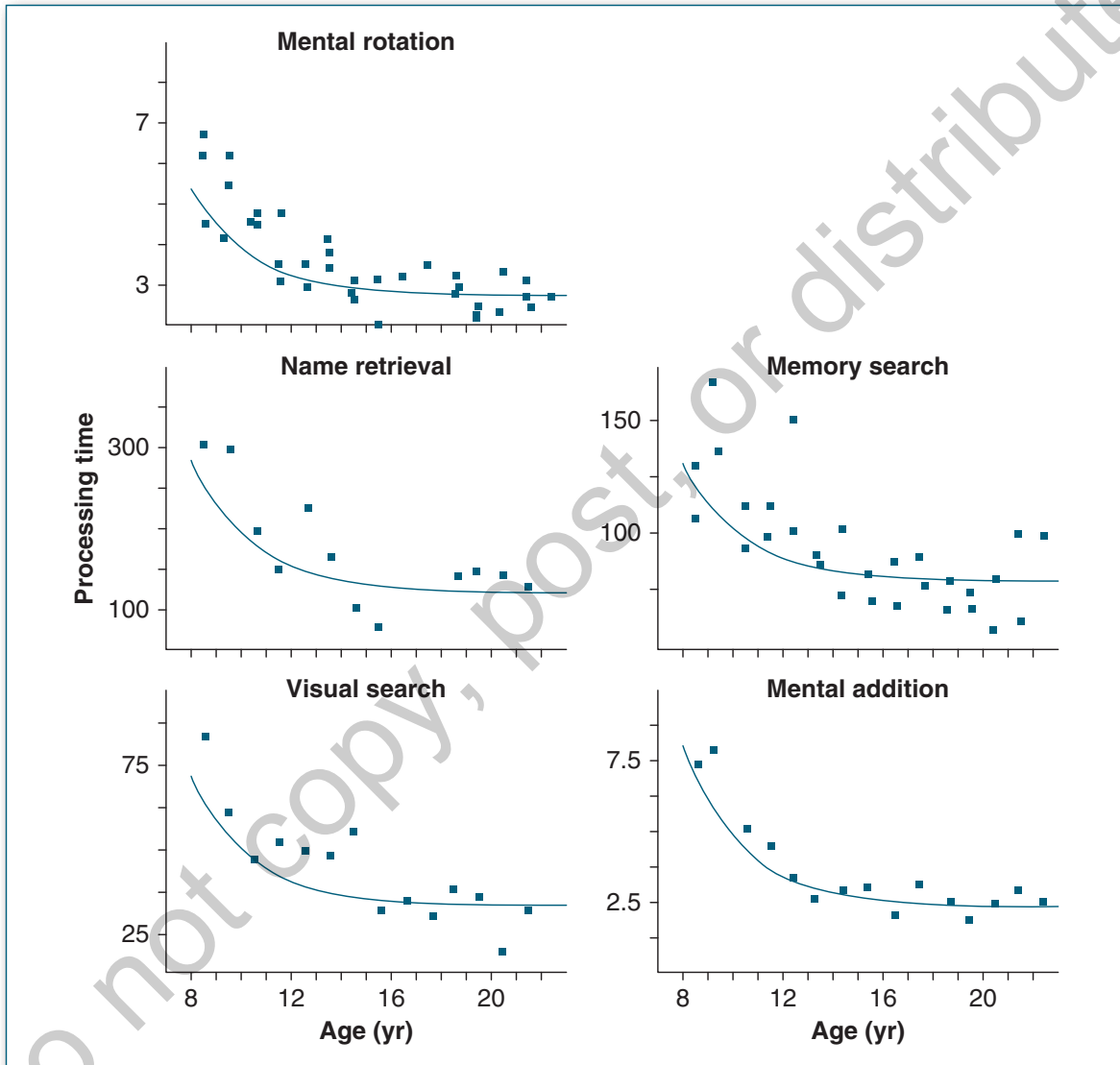
ability to work on a wider variety of tasks, especially complex ones. A second aspect of attention that shows developmental change is in children's ability to direct (and redirect) their attention—to shut out distractions and to concentrate on a particular task and to respond more quickly to the things they are focusing on (Plude, Enns, & Brodeur, 1994). Developmental psychologists use the term **executive functioning** to describe a person's ability to control her attention and direct processing resources, and executive functioning surely involves one or more components of working memory.

Work by Robert Kail (reviewed in Kail & Bisanz, 1992) provides one illustration of a general information-processing approach to cognitive development. Consider Figure 3.3, which presents results from several different studies conducted by Kail. In each, children, adolescents, and young adults performed various cognitive tasks, such as mental addition, searching through memory, and attempting to mentally rotate a visually presented stimulus. Processing time in each task showed the same general exponential decline. These results suggested to Kail that not only were adults and adolescents faster than children at a variety of cognitive tasks, but the rate at which they got faster showed a very similar pattern. This in turn suggested that there was a common, general mechanism at work: speed of processing.

But increases in capacity and speed are not the only things information-processing theorists see developing. They also attribute increased performance to changes in the knowledge base. Older children and adolescents simply know a lot more about a lot of topics than do younger children and certainly infants. Some information-processing theorists locate a major explanation for cognitive development in the growth of information older children have acquired.

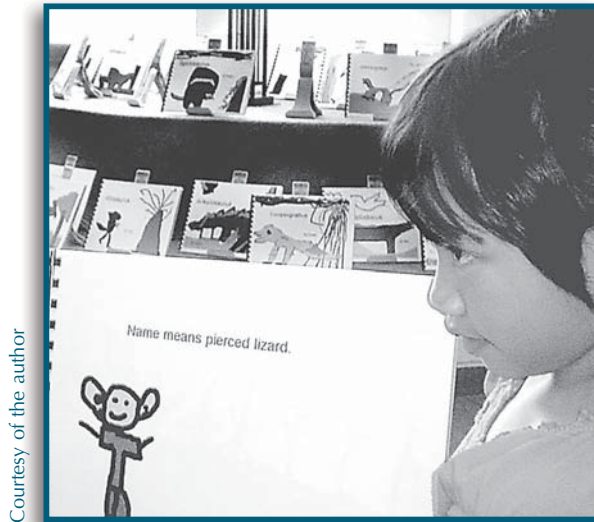
In a landmark case study, psychologists Michelene Chi and Randi Koeske (1983) studied a then 4.5-year-old, a known dinosaur fancier. The child had spent the previous 18 months acquiring information about dinosaurs from books read to him by his parents and from playing with the various plastic models he owned. Some dinosaurs were very familiar to him and were ones he had detailed knowledge of; other dinosaurs were less well known. On a variety of standard psychological memory tests, it turned out that the child performed much better when the stimuli were familiar dinosaur names than when the stimuli were less familiar dinosaur names. This result suggested that simply having more expertise in a domain enhances performance generally on tasks involving that domain. When we consider that older children typically have more expertise in almost every realm than younger children do, it suggests that a larger knowledge base might provide much of the explanation of cognitive differences. Adolescents and older children, having more experience in the world than younger children, have much more knowledge in a number of realms. Thus, they have more knowledge to bring to bear on a wider variety of problems.

Figure 3.3 Shown are developmental functions for rates of mental rotation, name retrieval, memory search, visual search, and mental addition. Data are taken from Kail, 1986, Experiments 1 and 2; Kail, 1988, Experiments 1 and 2



SOURCE: Kail and Bisanz (1992, p. 242).

NOTE: Rate of mental rotation is estimated by the slope of the function that relates response time (RT) to the orientation of the stimulus. Name retrieval is estimated by the difference between times for name and physical matching. Visual search is estimated by the slope of the function relating RT to the size of the search set. Memory search is estimated by the slope of the function relating RT to the size of the study set. Retrieval of sums on the mental-addition task is estimated from the slope of the function relating RT to the sum squared. The solid line depicts values derived from an exponential function in which the decay parameter, c , is the same for all five tasks.



Courtesy of the author

Photo 3.1 Information-processing theory notes that during middle childhood, children acquire a great deal of knowledge about a variety of topics, facilitating their cognitive processing of information within those domains.

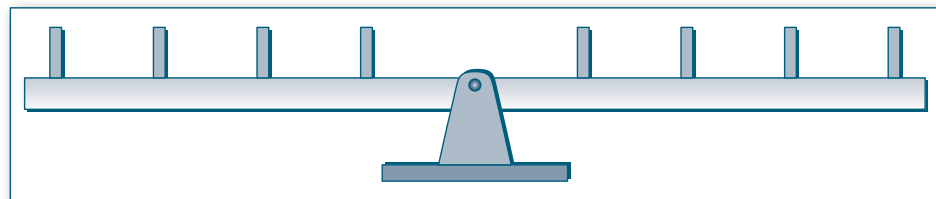
Certainly the ability to process and produce language has been touted as a crucially important cognitive ability that in turn might affect cognitive processing generally. Being able to use language to direct one's attention and performance on a task—that is, being able to “talk oneself through” a task—has been regarded as a major achievement.

Younger children are also less likely than older children or adolescents to plan ahead or to use **strategies**, or deliberate plans of problem solving, on cognitive tasks. For example, if given a set of stimuli and asked to study them, older children are much more likely to adopt useful study behaviors, such as **rehearsal** (repeating the information, either aloud or silently), than are preschoolers (Flavell, Beach, & Chinsky, 1966).

Moreover, adolescents and older children may have different approaches or strategies to use on problems than do younger children. The research of psychologist Robert Siegler (1981, 1982) provides one example. He and his colleagues developed the **rule assessment approach** to the study of conceptual development in children and adolescents. The basic assumption is that some aspects of conceptual development are best characterized by “a sequence of increasingly powerful rules for solving problems” (Siegler, 1982, p. 272).

Consider, for example, balance scale problems, depicted in Figure 3.4. Children and adolescents are presented with the apparatus shown. Weights can be added to either side of the scale and can be placed either close to

Figure 3.4 Balance scale apparatus



SOURCE: Siegler (1981, p. 7).

or farther away from the center point of the scale, called the *fulcrum*. Prediction of whether or not the scale will balance or tip toward one side depends on taking into account both the amount of weight and the distance from the fulcrum.

Siegler (1981) found that four different rules can be used to predict how children and adolescents will perform on balance scale problems. These are shown in Figure 3.5. Rule I is the simplest rule—it takes into account only information about one dimension (in this case, the amount of weight on each side of the fulcrum). Rule II adds on to this the idea that if the weight on both sides is equal, then the information on the subordinate dimension (in this case, distance from the fulcrum) is considered. Rules III and IV show increasing amounts of complexity in considering information.

To assess which rule a particular student might be using, Siegler (1981) designed six different types of problems, shown in Figure 3.6. This figure shows that if a student was using Rule I, she should correctly predict answers to Problem Types 1, 2, and 4, but not to any of the others. A student using Rule IV should make correct predictions on all problems.

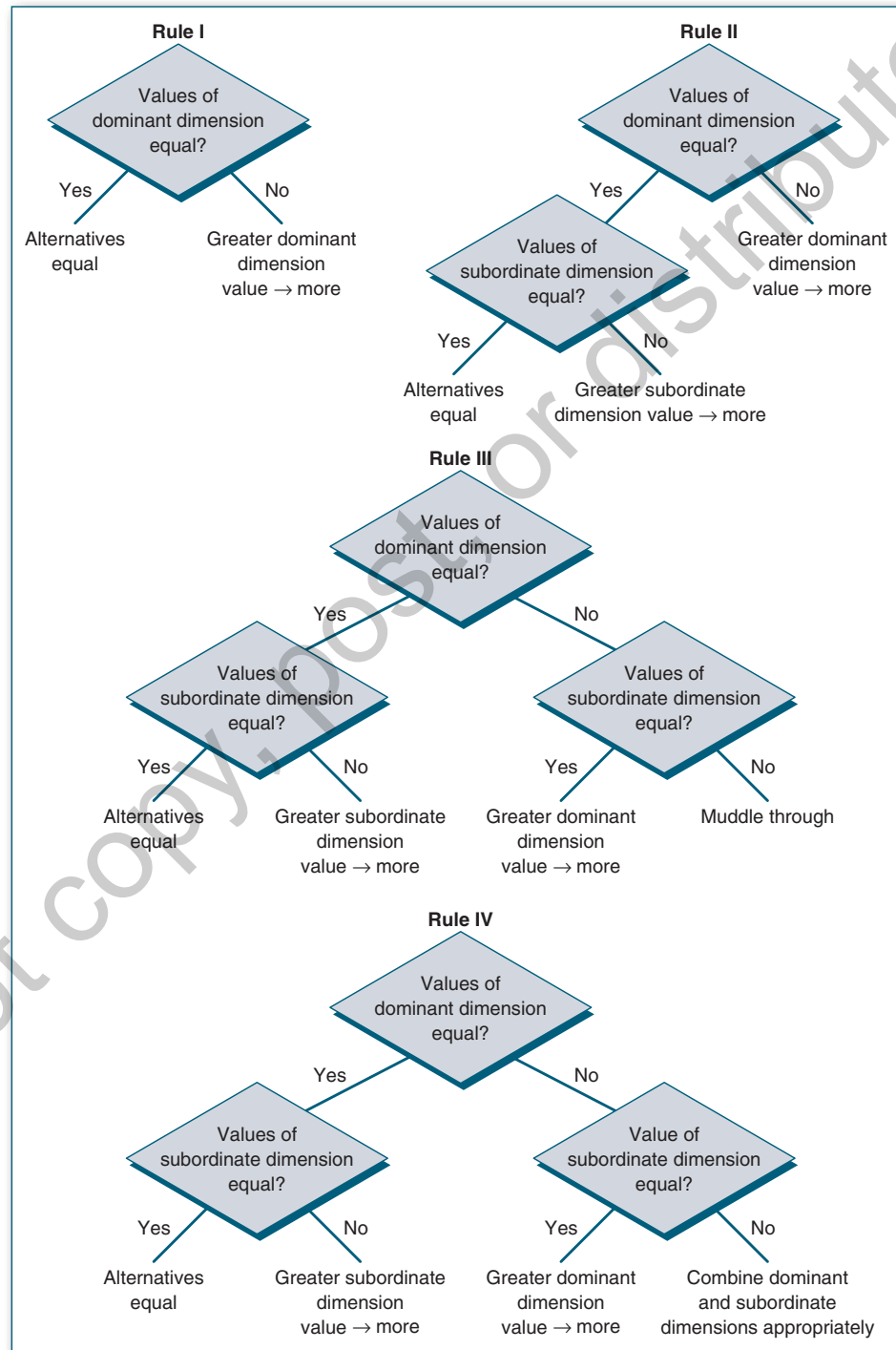
As might be expected, Siegler (1981) found that younger children used less complex rules (on both the balance scale problems described here and other kinds of problems he investigated). Preschoolers overwhelmingly used either no discernable rule or Rule I. Eight-year-olds mostly used Rules II and III, with a few still using Rule I and a few using Rule IV. Most 12-year-olds used Rule III, with a few using Rules II or IV. The data for adults looked quite similar to the data for the 12-year-olds. Siegler's point is that differing knowledge states predict different ways of solving problems and suggest differences in the way information about a problem will be encoded and used.

Kail and Bisanz (1992) attempted to distill the core aspects of the information-processing approach into a list of some key assumptions. First and foremost is the idea that information can and is represented internally, and these mental representations undergo manipulation in real time. Again, the analogy most often used is that to the way computers operate.

A second assumption is that all cognitive activity stems from the operation of a relatively small number of elementary cognitive processes. That is, all the cognitive things we do—reading, solving problems, navigating through an area with a map, recognizing an old acquaintance—stem from the operation of a relatively small set of basic cognitive processes, which operate in concert. It's the goal of the information-processing approach to specify just what these processes are and how they interact.

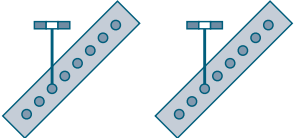
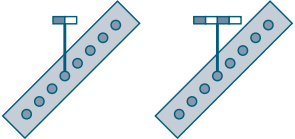
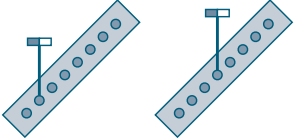
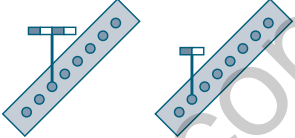
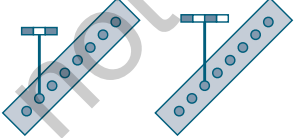
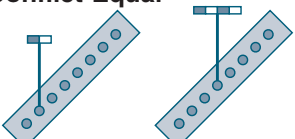
Finally, the information-processing framework explains cognitive development in terms of the self-modification of the elementary processes. That is, the individual processes are assumed to modify themselves—increasing

Figure 3.5 Modal rule models



SOURCE: Siegler (1981, p. 6).

Figure 3.6 Predictions of percentage of correct answers and error patterns for children using Rules I through IV on balance scale task

Problem type	Rules			
	I	II	III	IV
Equal 	100	100	100	100
Dominant 	100	100	100	100
Subordinate 	0 (should say "Equal")	100	100	100
Conflict-Dominant 	100	100	33 (chance responding)	100
Conflict-Subordinate 	0 (should choose right side)	0 (should choose right side)	33	100
Conflict-Equal 	0 (should choose right side)	0 (should choose right side)	33 (chance responding)	100

SOURCE: Siegler (1981, p. 10).

capacity, becoming faster or more efficient, becoming more elaborated. Although the impetus for this self-modification may come from external sources (e.g., a child learns more information about a topic and thus has a larger and more integrated knowledge base about that topic), the final result is that internal processes undergo alteration.

Learning Theory

Psychologists who study learning (both animal and human) focus on how an organism's experience causes changes in the way that organism responds to future events. In order for this past experience to have an influence, of course, there must be some means of the organism representing past experience—perhaps through a change in the basic neural wiring or some other connections that the organism may or may not have explicit awareness of. Learning theorists initially believed that the laws of learning were ones that applied to all kinds of learning and all kinds of organisms—a dog learning to bark on command, a child learning when a favorite television program comes on, a scientist learning a new principle of thermodynamics. Although most psychologists reject the belief that one set of learning laws exists for all kinds of learning (Gleitman, Fridlund, & Reisberg, 2004), many of the basic principles of learning discovered do have wide applicability to many kinds of learning. Here, we will concentrate on three major forms of learning: classical, instrumental (or operant), and social.

Classical conditioning builds on the hardwired reflexes an organism is born with. As you may recall, reflexes have two parts—(a), a stimulus, which elicits (b), a response. In order for something to be considered a hardwired reflex, the stimulus must always automatically elicit the response, regardless of the animal's prior experience or current beliefs. Consider, as an example, the reflexive kick your leg gives when your knee is tapped in just the right spot. The tap to the knee is the stimulus, and the kick of the leg is the response.

Ivan Pavlov (1849–1936), a Russian physiologist, was the first to discover that an organism could acquire, or learn, new reflexes, which, although more fragile than hardwired ones, could come to work just as automatically. Acquired, or conditional (later mistranslated as “conditioned”), reflexes were built upon the hardwired reflexes by pairing a previously neutral stimulus, called a *conditioned stimulus*, with the eliciting stimulus from the hardwired reflex, called the *unconditioned stimulus*. After a number of such pairings, a new, conditioned reflex is built, such that the conditioned stimulus presented alone comes to elicit the conditioned response (which in most cases is similar to the unconditioned response).

For example, suppose that we arranged for you to have 50 exposures of a knee tap but each time arranged to sound a bell just before the hammer tapped your knee. According to the principles of classical conditioning, the 51st presentation of the bell (without the hammer this time) should be sufficient to cause your knee to kick.

Classical conditioning has been shown in infants. One of the most famous, and controversial, demonstrations of this came in the case of Little Albert. Psychologist John B. Watson and his graduate student Rosalie Rayner (1920) tested 11-month-old Albert B., pairing the sight of a white rat (CS, or *conditioned stimulus*) with the unexpected and loud sound of a steel bar being struck behind him (UCS, or *unconditioned stimulus*) in order to produce a conditioned fear response. They later found that this fear response *generalized* (that is, started to appear in response) to other, similar stimuli, including a white rabbit and a Santa Claus mask. Although Watson and Rayner were not the first to demonstrate classical conditioning in children (Windholz & Lamal, 1986), their case study is undoubtedly the most well known. Later studies have established (with fewer ethical issues) that given the right stimuli, even hours-old newborns can be classically conditioned (Rovée-Collier & Barr, 2001), a point we will return to in Chapter 4.

Although classically conditioned responses are fairly easy to establish, they don't explain a wide range of learned behaviors, simply because all classically conditioned responses must be built upon existing hardwired reflexes, the repertoire of which is fairly limited. Fortunately, there exists another route to establishing new behavioral responses, known as **instrumental** (sometimes **operant**) **conditioning**. Instrumental conditioning relies on a principle known as the *law of effect* (Thorndike, 1898): Responses followed by rewards tend to be strengthened, while those followed by no reward or punishment are weakened. For example, if a toddler throws a hissy fit in the grocery store (response) and that response is followed by something "rewarding" (e.g., the parent buys her a candy bar at the checkout lane, just to quiet her), the tantrum response is likely to become more frequently emitted in the future. On the other hand, a toddler whose fits go unheeded is, according to this account, likely to show this response less frequently in the future. We'll see examples of instrumental conditioning used to investigate especially the cognitive capabilities of infants in Chapters 4 and 5.

Learning theory makes predictions about an individual's current performance based on that individual's past experiences. The general idea is that most of the reason an organism does what it does or experiences what it experiences has to do with what its prior encounters have been.

Learning theory was developed largely in animal laboratories. This makes good sense, as experiments in learning laboratories typically measure behavioral responses—either heart rates or eye blinks or lever presses—rather than long verbal reports on feelings or thoughts. It's no surprise, then, that learning theory provides developmental psychology with a variety of useful methodologies for studying the preverbal infant.

Take, for example, the question, “What capabilities do newborn infants have to see, hear, taste, smell, and feel, and how do those capabilities change in the months after birth?” Although the question seems straightforward, it's a lot harder to answer than it might first seem. The challenge, of course, is that infants don't communicate in language, making standard approaches to sensory testing unusable. We can't have them read an eye chart or raise their hand when they hear a tone. Therefore, researchers studying infant perception have to devise clever means of detecting what kinds of stimuli the infants detect.

Animal researchers in the learning theory tradition got around this dilemma by using a well-known finding from the laboratory: Organisms show **habituation** to familiar stimuli. That is, when they repeatedly encounter the same stimulus, they appear to “tune it out” and pay less attention to it. This finding can be exploited in research to ask if an animal can discriminate between two stimuli as follows: First, present Stimulus A and note the animal's reaction (e.g., by recording heart rate, measuring how long the animal looks at it, or rating the apparent attention to it). Then continue to present Stimulus A until the animal “shows less interest” (e.g., heart rate decelerates to a baseline level, the animal looks away, or the raters judge the animal to not be paying attention). Now either present Stimulus A again (if this is a “control” trial) or present Stimulus B. If the animal does detect a difference between the two stimuli, the reaction to Stimulus B ought to be different from the reaction to the repeat presentation of Stimulus A. If the animal looks longer at B, shows an increase in heart rate when presented with B (relative to when presented with A), or seems more interested in B than A, researchers conclude that the animal perceives a difference between A and B. We say that the animal has *dishabituated* to Stimulus B. Now substitute the word *infant* for *animal* in the above description, and you have a recipe for how experimenters can “ask” nonverbal infants about whether they perceive two stimuli as the same or different.

Learning theory is also relevant to cognitive development in older children. Learning theorist Edward Thorndike (1874–1949) pioneered basic concepts in instrumental conditioning that applied to animal learning. He was also known for his work in educational psychology, particularly in the study of how children learn arithmetic (Thorndike, 1925; R. Thorndike,

1991). Thorndike is most famous to introductory psychology students as the discoverer of the *law of effect*—the basic principle of instrumental conditioning, which states the following:

Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will, other things being equal, have their connections with that situation weakened, so that, when it recurs, they will be less likely to occur. The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond. (Thorndike, 1911/2000, p. 244)

We see in this quote the idea that learning consists of the formation of bonds or connections that get strengthened through repetition and when they are followed by positive reinforcement. Thorndike brought these ideas to the study of how children learn arithmetic. For example, he believed in the idea that children learn associations between problems such as $8 + 7 = ?$ and 15 through lots of repetition and practice. He advocated preparing realistic problems and giving children repeated opportunities to strengthen these bonds.

Similarly, in studying how best to teach children to read, Thorndike analyzed texts (books, magazines, newspapers) to see how frequently different words appeared. Again, the emphasis was on analyzing a complex task (such as reading) into component associations that needed to be learned so that appropriate amounts of practice could be devoted to critical bonds or associations.

A more recent offshoot of learning theory is *social learning theory*, developed in the 1930s (Miller, 2011). It held that learning can occur without a direct reinforcement, such as a UCS in classical conditioning or a reward or punishment in operant conditioning. Instead, real-world learning can happen simply through a learner observing a model. That learning might not be immediately expressed in any observable behaviors, but under the right conditions or with the right incentives, the learning will be displayed.

Social learning theory focuses (unsurprisingly) on the social aspects of a child's development, looking to explain how a child comes to imitate certain models and not others. However, the theory assumes that a lot of social learning involves *cognition*—forming a mental representation of the behaviors a model displays, storing that representation, and figuring out when to use it to guide one's own behavior.

Darrin Klimek/DigitalVision/Thinkstock



Photo 3.2 Social learning theory examines explanations for how children learn to imitate models to produce new behaviors.

Arguably, one of the most well-known studies in social learning theory was done by Bandura, Ross, and Ross (1961). Preschool children watched while an adult model displayed various forms of aggression against a large inflated “Bobo doll” (in my youth, gas stations used to give these away as premiums—they stand about 3–4 feet tall and have sand in the bottom such that if you punch them, they pop right back up). The model would hit the Bobo doll in the head with a hammer or punch it in the head while saying relatively novel things such as, “Sock him in the nose.” Other children saw an adult model play with Tinkertoys (another blast from my past!) or saw no model. Later, all of the children were given the opportunity to play in a playroom with a variety of toys, including a Bobo doll. Children in the first group were more aggressive in their play than the other groups, both in terms of their direct imitation of the model (e.g., hitting the Bobo doll) and more generally.

Learning theory, including social learning theory, represents an empiricist tradition in psychology. **Empiricism** is a philosophical tradition that places much less emphasis

on inborn, hardwired cognitive architecture and much more emphasis on acquired behavior, learned from the environment. If you think about the traditional “nature–nurture” question, empiricism is on the end of the “nurture” dimension. Philosopher John Locke (1632–1704), for example, bequeathed us the metaphor of the mind as a blank slate (*tabula rasa*) at birth—with one’s individual experiences doing the writing.

The Modules and Core Knowledge Approach

The corresponding philosophical position, **nativism**, places much more emphasis on knowledge structures that an infant is, in some sense, born with. As such, nativism falls on the “nature” end of the nature–nurture continuum. Philosophers such as John Stuart Mill (1806–1873) and Immanuel Kant (1724–1804) discussed the existence of preexisting categories of knowledge. Sometimes this knowledge takes a while to mature or unfold, but the idea is that the knowledge is genetically programmed to appear at some point, given a normal environmental experience.

Philosopher Jerry Fodor (1983), for example, proposed that some cognitive processes—in particular, perception and language—are *modular*. What does this mean? First, it means the process is *domain specific*: It

operates specifically with certain kinds of input and not others. With regard to language, for example, Fodor argued that understanding a spoken or written sentence involves processes that are specific to the division of phrases and words into constituents. Similarly, perceptual processes are only used to carry out the task of recognizing meaningful stimuli—not for problem solving or memory or reasoning. Modular processes (called *modules*) are meant only for a specific kind of task and are of little use in other cognitive tasks. **Modularity** of a process also implies that it operates independently of other processes, as opposed to working cooperatively with them. Modular processes operate automatically and independently (at least at the first stages of processing) of other nonmodular cognitive processes, such as thought or memory.

Modular processes are thought to be innate. That doesn't mean that they will be fully functional at birth, nor that they are completely independent of environmental input. It does mean that, given a wide range of normal environments, the processes will show similar patterns of emergence even in very different cultures. Although there are examples of extreme deprivation causing severe stunting in a particular realm, the existing examples are quite rare (as well as quite heart wrenching). A nativist might explain that it takes an intense degree of environmental disruption to disturb the development of a modular process.

Developmental psychologist Elizabeth Spelke (Spelke & Kinzler, 2007) proposed that infants are innately endowed with four cognitive systems: one for representing objects, one for representing actions, one for representing number, and one for representing space. She posits as well that a fifth system, one for representing social patterns, may also exist. We'll take a very detailed look at this proposal in Chapter 4. For now, I want to explore the meaning it has to say that an infant possesses a innate system. Obviously, it cannot mean that an infant can articulate all the principles of that system in words. What it does mean, in contrast, is that infants come into the world prepared to make certain assumptions, entertain certain hypotheses, or hold certain expectations of the way objects will or won't behave.

We will also see a strong nativist influence on many researchers who study language development. Noam Chomsky, arguably the most famous modern linguist, for example, has argued that human beings come equipped with a **language acquisition device (LAD)** that programs them to acquire a human language by the end of early childhood (Chomsky, 1968). His argument was



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Photo 3.3 Nativists explain that some processes, such as perception, are very hard (but not impossible) to disrupt in normal environments.

that while the child's environment dictated *which* human language would be acquired, the LAD constrained the learning to a human language as opposed to an artificial one (such as, let's say, HTML or Python).

Nativists such as Chomsky therefore don't necessarily argue that specific knowledge is innate. Rather, the argument goes something like this: Part of what it means to be human is to have certain structures programmed into us that constrain and direct our learning. Thus, we come "prepared" to learn some things, such as language or perception, rather easily when compared with other domains. This explains, for example, why a 3-year-old has learned a lot of sophisticated information about her native language but has learned very little about calculus or formal logic.

A Cognitive Neuroscience Perspective

Many of the general age-related changes in cognitive development are believed to stem from underlying changes in neurological development (Spann, Bansal, Rosen, & Peterson, 2014). Certain brain structures such as the cerebellum, hippocampus, and cerebral cortex don't assume their final mature state until well into childhood or adolescence. As brain structures mature, certain cognitive achievements in such realms as vision, face recognition, and visual tracking are observed. So-called *higher mental processes*, such as planning and goal setting, have been linked to the final maturation of the frontal cortex during the adolescent years. And as we will see, neurological development of the prefrontal cortex has been tied to development of executive functioning (Casey, Giedd, & Thomas, 2000).

Of course, the topic of brain development and its relationship to cognition is itself a vast and complex one, and only brief highlights are given here. The interested student is referred to other in-depth treatments of the topic (e.g., Johnson, Munakata, & Gilmore, 2002). First, some growth statistics: The weight of the brain grows from 0 to 350 grams (350 grams is a little less than 13 ounces) during the prenatal period, but it doesn't stop then. The maximum brain weight of 1,400 grams (a little more than 49 ounces) is achieved when the individual is about 11 years old (Nolte, 2009). Most of the postbirth growth takes place before the child's fourth birthday, although some changes continue through adulthood, with a slow decline setting in at about age 50.

There are obviously many different structures to discuss when we talk about the brain. Figure 3.7 shows various structures of the brain, including the hindbrain, midbrain, and forebrain, and how they develop prenatally. In our brief discussion, we will focus specifically on the cerebral cortex, a part of the forebrain. However, it is worth briefly talking about the hindbrain and midbrain first.

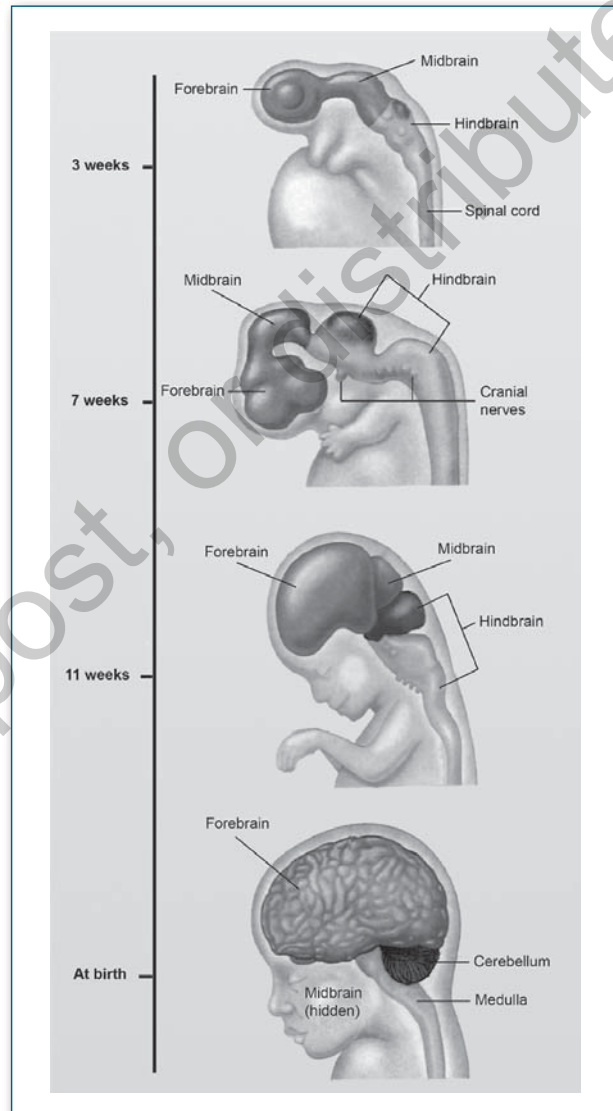
The **hindbrain** contains three major structures. The *medulla* transmits information from the spinal cord to the brain and regulates life support functions such as breathing. The *pons* also acts as a neural relay center, facilitating the “crossover” of information between the left side of the body and the right side of the brain and vice versa. The *cerebellum* contains neurons that coordinate muscular activity and coordination.

The **midbrain** is “a small region of enormous importance” (Nolte, 2009, p. 675). Many of the structures (e.g., the *inferior* and *superior colliculi*) are involved in relaying information between other brain regions (e.g., the cerebellum and forebrain). Another midbrain structure, the *reticular formation*, helps keep us awake and alert and is involved in the sudden arousal we might need to respond to a threatening or attention-grabbing stimulus.

The **forebrain** also consists of a number of structures. The *thalamus*, for example, is yet another structure to relay information, especially to the cerebral cortex, about which more information is given below. The *hypothalamus* controls the pituitary gland by releasing *hormones*, specialized chemicals that help regulate other glands in the body. The hypothalamus also controls so-called *homeostatic behaviors*, such as eating, drinking, temperature control, sleeping, sexual behaviors, and emotional reactions (Wilson, 2003). Other structures, such as the *hippocampus*, *amygdala*, and *septum*, have to do with memory and emotional experience and regulation, and the *basal ganglia* are involved in the production of motor behavior.

We will focus here on the *cerebrum* (from the Latin word for “brain”), the largest structure in the brain. It contains a layer called the **cerebral**

Figure 3.7 Development of major structures of the brain



SOURCE: Garrett (2015, p. 57).

cortex, consisting of about a half-dozen layers of neurons with white matter beneath that carries information between the cortex and the thalamus or between different parts of the cortex.

Figure 3.8 presents a more detailed diagram of the cerebral cortex, which neurologists divide into four lobes: **frontal** (underneath the forehead); **parietal** (underneath the top rear part of the skull); **occipital** (at the back of the head); and **temporal** (on the side of the head). Actually, since our heads have two sides, right and left, we have two lobes of each kind—the right frontal, left frontal, right parietal, left parietal, and so forth. The left and right hemispheres are connected by either the *corpus callosum* (in the case of the frontal, parietal, and occipital lobes) or the *anterior commissure* (in the case of the temporal lobes; Nolte, 2009).

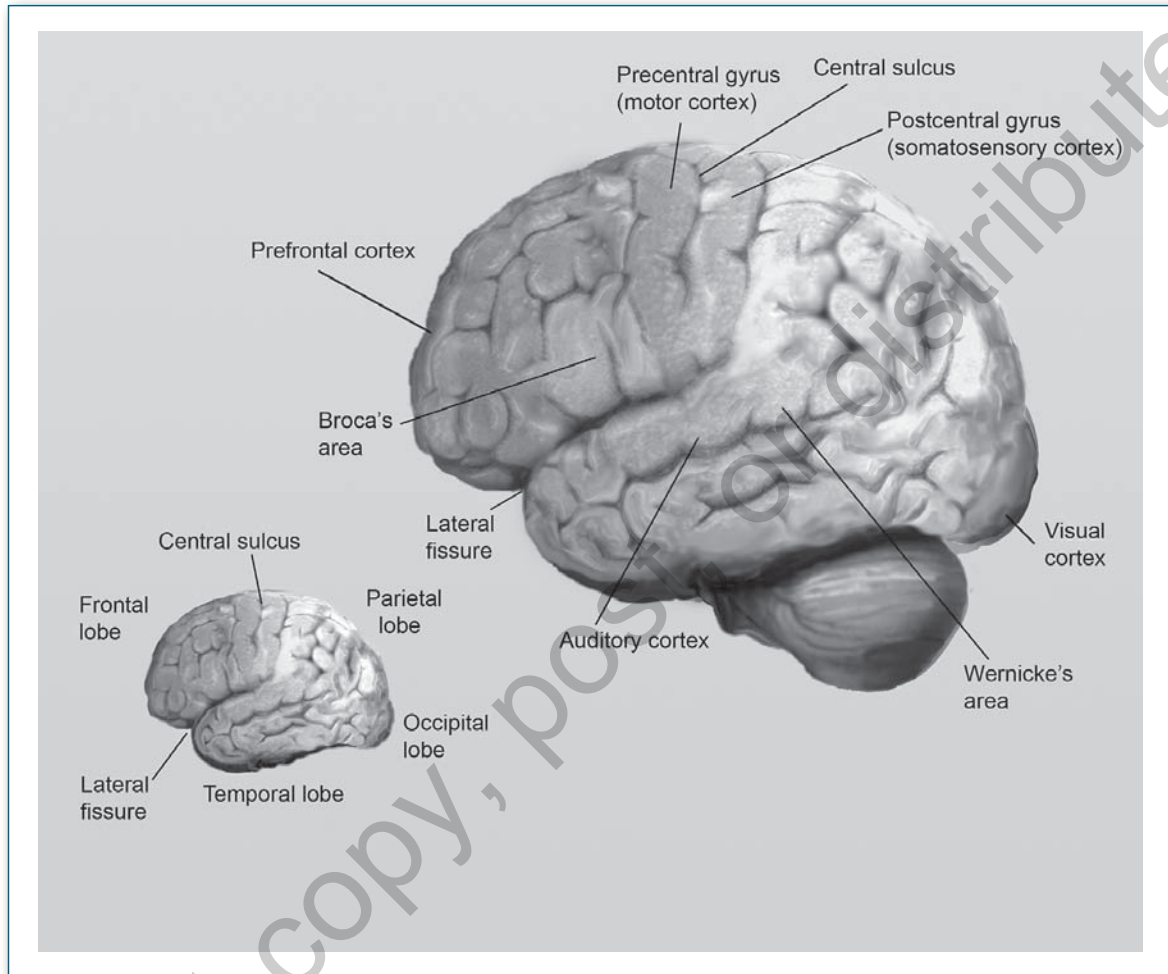
The parietal lobes contain the somatosensory cortex, involved in the processing of sensory information from the body—for example, sensations of pain or pressure, touch or temperature (Garrett, 2009). The occipital lobes process visual information, and the temporal lobes process auditory information, as well as information from the senses of taste and smell (Nolte, 2009). The temporal lobes are also right above structures such as the amygdala and hippocampus, both involved in memory, so damage to the temporal lobes can result in memory disruption as well.

The frontal lobes have three separate regions. The *motor cortex* directs fine motor movement, while the *premotor cortex* (right in front of the motor cortex) seems to be involved with planning such movements. The **prefrontal cortex** or lobe is involved with what neuropsychologists call executive functioning—planning, making decisions, implementing strategies, inhibiting inappropriate behaviors, and using working memory to process information (Nolte, 2009).

The prefrontal cortex also shows the longest period of maturation, and it appears to be one of the last brain regions to mature (Casey et al., 2000). Interestingly, this region may also be one of the “first to go” in aging effects seen toward the end of life. It has been hypothesized that brain regions that show the most plasticity over the longest periods might be the most sensitive to environmental toxins or stressors.

The cognitive neuroscience approach to studying cognitive development is to chart the growth of these various brain regions and structures and to try to relate their growth directly to performance on specific cognitive tasks. For example, a developmental cognitive neuroscientist might study the brain changes that accompany or predict the development of memory strategies in school-age children. We’ll see specific examples of the cognitive neuroscience approach in the chapters to come.

Figure 3.8 Cerebral lobes and functional areas on the surface of the cerebral hemispheres



SOURCE: Garrett (2015, p. 60).

Dimensions of Cognitive Developmental Theories

The theories we have covered in this chapter and Chapter 2 share similarities and differences. Here, I want to highlight three major dimensions along which theories can be ordered. The first is the *nature–nurture dimension*, which essentially has to do with how much emphasis the theory places on innate (or inborn) structures versus how much emphasis the theory places on experience and learning. Obviously, learning theories are on the nurture end of the spectrum, while nativist theories are on the nature end; theories such as Piaget's fall in the middle, with other theories also somewhere in between.

A second important dimension is the *continuity–discontinuity dimension*. This has to do with how much a theory postulates continuous, incremental, gradual change versus how much it regards development as having abruptly appearing qualitative change. Here, stage theories are likely to fall closer to the “discontinuity” end of the spectrum, and learning and information-processing theories closer to the “continuity” end.

Finally, a third dimension of difference is the *universal culture-specific dimension*. This has to do with whether a theory is assumed to hold across all cultures and time periods or whether it is to be offered as a description of development specific to one or more particular contexts. Theories that posit general laws or axioms fall more toward the first end; theories that don’t fall toward the second.

● RESEARCH METHODS FOR STUDYING COGNITIVE DEVELOPMENT

Throughout the book, I will be presenting a number of studies in developmental psychology, some of them in great detail. When reading about a study’s conclusions, it is essential to keep in mind how those conclusions have come about. Doing this requires an understanding of **research methods**. Whole courses in research methods exist in almost every psychology department; therefore, my treatment of the topic in one section of one chapter will necessarily be brief. If you’d like to follow up on any issues I touch on here, I’d refer you to Scott A. Miller’s *Developmental Research Methods* (2012), a textbook on research methods in developmental psychology.

Longitudinal Versus Cross-Sectional Designs

I presented the terms *longitudinal* and *cross-sectional* back in Chapter 1 but will provide a brief reminder here. In a longitudinal design, a researcher gathers a group of participants and follows them over time, noting changes in whatever is being studied as the group of participants ages. Longitudinal designs are expensive to run and subject to problems in interpretation if too many participants drop out of the study. Moreover, they are often problematic in confounding history with development. For example, children first recruited in 2005 in New Orleans are likely to be forever changed by their experiences living through Hurricane Katrina—a historical event that other similarly aged children from, say, California or Massachusetts didn’t experience. In the same way, individuals who grew up during an economic depression or a world war are likely to be

affected by those historical events in ways that are not readily detangled from other, routine developmental influences.

On the plus side, longitudinal designs do help a researcher control for a variety of individual differences. Stable aspects of a participant—certain personality characteristics or certain intellectual characteristics—presumably remain fairly constant over time and are thus not likely to explain changes in cognitive functioning over time.

In a cross-sectional design, different groups of participants of different ages are tested and compared—for example, one group of children aged 4 in the year 2015 is compared with another group of children aged 10 in 2015. Cross-sectional designs are subject to so-called **cohort effects**. Imagine a study comparing current (in 2015) 5-year-olds with current (in 2015) 25-year-olds on their memory for traumatic events. The older group lived through the events of 9/11, for example, and arguably experienced a national tragedy that “left its mark” on them in a way that the younger group did not. Thus, what might look like a developmental effect—that older individuals have different memories for trauma—might instead reflect a cohort effect: People who’ve lived through a tragedy remember other tragedies differently than people who haven’t. Cross-sectional designs typically are cheaper and faster to run than longitudinal ones, however, so we will see several examples of these kinds of studies in the book.

Observational Studies and Clinical Interviews

As the name itself suggests, **observational studies** are those in which the researcher observes children and records some aspect of their behavior. For example, the researcher might “hang out” in a preschool and record the number of times one child tries to mislead or deceive another one. Ideally, the observer remains as unobtrusive as possible so as not to disrupt or alter the behaviors being observed. In this example, for instance, the investigator might spend several days in the classroom with the children so that they can get used to her presence and stop “performing” for her audience.

Observational studies have the advantage that the things studied really do occur in the real world and not just in an experimental laboratory. Psychologists call this property **ecological validity**. Furthermore, the observer has a chance to see just how cognitive processes work in natural settings: how flexible they are, how they are affected by environmental changes, how rich and complex actual behavior is. Observational studies are relatively easy to conduct and don’t typically introduce ethical issues. We’ll see many examples of observational studies throughout the book.

Clinical interviews are one extension of observational studies, where the investigator exercises a little more direction and influence than in observational studies but tries very hard to allow the participant to respond freely and normally. The investigator begins by asking each child one or more open-ended questions. For example, the interviewer might ask a child how he or she typically tries to pay attention to the teacher in school. The child gives an open-ended response, but the interviewer may follow up with another set of questions. Depending on the child's responses, the interviewer may pursue one or another of many possible lines of questioning, trying to follow each participant's own thinking and experience while focusing on specific issues or questions. We'll see shortly that the clinical interview was a method favored by Piaget in his work with his own infant children—although in this case, the “questions” he asked were actually nonverbal stimuli he presented. He then watched and recorded how his children responded to these stimuli.

Correlational Studies

Correlational studies are related to observational studies in that measures of behavior are observed. Correlational studies typically involve an investigator measuring two or more things and assessing the degree of linear relationship between them. For example, a cognitive developmental psychologist might measure both the attention span and the working memory capacity of a group of children and compute the **correlation**, or degree of linear relationship, between these two dependent variables.

Correlational studies are good for establishing the existence of relationships between different measures. However, correlational studies are limited in that they cannot establish causal relationships. If a researcher finds that Measures A and B have a strong correlation (correlations range from an absolute value of 0 to an absolute value of 1), he cannot tell if A causes B, if B causes A, or if some other variable causes both A and B.

Experimental Studies

Experimental studies are ones in which an investigator exercises some degree of *experimental control*. Having experimental control means the experimenter can assign participants to different experimental conditions so as to minimize preexisting differences between them. Ideally, the experimenter can control all variables that might affect the performance of research participants *other than* the variables on which the study is focusing. A true **experiment** is one in which the experimenter manipulates one

or more independent variables (the experimental conditions) and observes how the recorded measures (dependent variables) change as a result.

For example, an experiment in cognitive developmental psychology might proceed as follows: An experimenter recruits a number of same-aged children for a study of voluntary attention span, randomly assigns them to one of two groups, and presents each group with exactly the same stimuli, using exactly the same procedures and settings and varying only the instructions (the independent variable) for the two groups of children. The experimenter then observes the overall performance of the participants on a later test of attention span (the dependent variable).

This example illustrates a **between-subjects design**, wherein different experimental participants are assigned to different experimental conditions and the researcher looks for differences in performance between the two groups. In contrast, a **within-subjects design** exposes experimental participants to more than one condition. For example, participants might perform several attention span tasks but receive a different set of instructions for each task. The investigator then compares the performance of the participants in the first condition to the performance of the *same* participants in another condition.

Quasi-Experimental Studies

Some types of studies, especially those in developmental psychology, preclude random assignment (that is, they have the experimenter assign a research participant to a particular condition in an experiment). For example, experimenters cannot assign participants to different ages or developmental statuses; they have to take people as they come with respect to age. Studies that appear in other ways to be experiments but that have one or more of these factors as independent variables (or fail to become true experiments in other ways) are called **quasi-experimental designs** (Campbell & Stanley, 1963).

Scientists value experiments and quasi-experiments because they enable researchers to isolate causal factors and make better-supported claims about causality than is possible using observational or correlational methods alone. However, many experiments fail to fully capture real-world phenomena in the experimental task or research design. The laboratory setting or the artificiality or formality of the task may prevent research participants from behaving normally, for example. Further, the kinds of tasks amenable to experimental study may not be those most important or most common in everyday life. As a result, experimenters risk studying phenomena that relate only weakly to people's real-world experience.

Studies of Brain Functioning

Up until fairly recently, researchers interested in how a brain functioned usually had to wait until a patient died to perform an autopsy to correlate, say, his or her cognitive problems with a particular area of brain damage. Early in the 20th century, more information was gleaned from the reports of neurosurgery performed on patients who had severe epilepsy or a suspected tumor in a particular location. Notice, though, that the brains of healthy people were not explored (fortunately for them, unfortunately for science!).

In the last few decades, however, researchers have developed a number of relatively noninvasive techniques for studying the brains of healthy individuals, including infants. Collectively, these are known as **brain imaging** techniques. There are various kinds of techniques that differ in their use of radioactive materials, the relative degree of clarity of the output, and the amount of time it requires to obtain a scan. Among the older techniques are such things as **PET scans** (PET is an acronym for *positron emission tomography*) and CT or **CAT scans** (CAT stands for *computerized axial tomography*). PET scans require an injection of a radioactively labeled compound, and CAT scans require exposure to X-rays, so neither one is appropriate for casual, repeated use. We will focus here on two more commonly used and more recently developed techniques: MRI and fMRI.

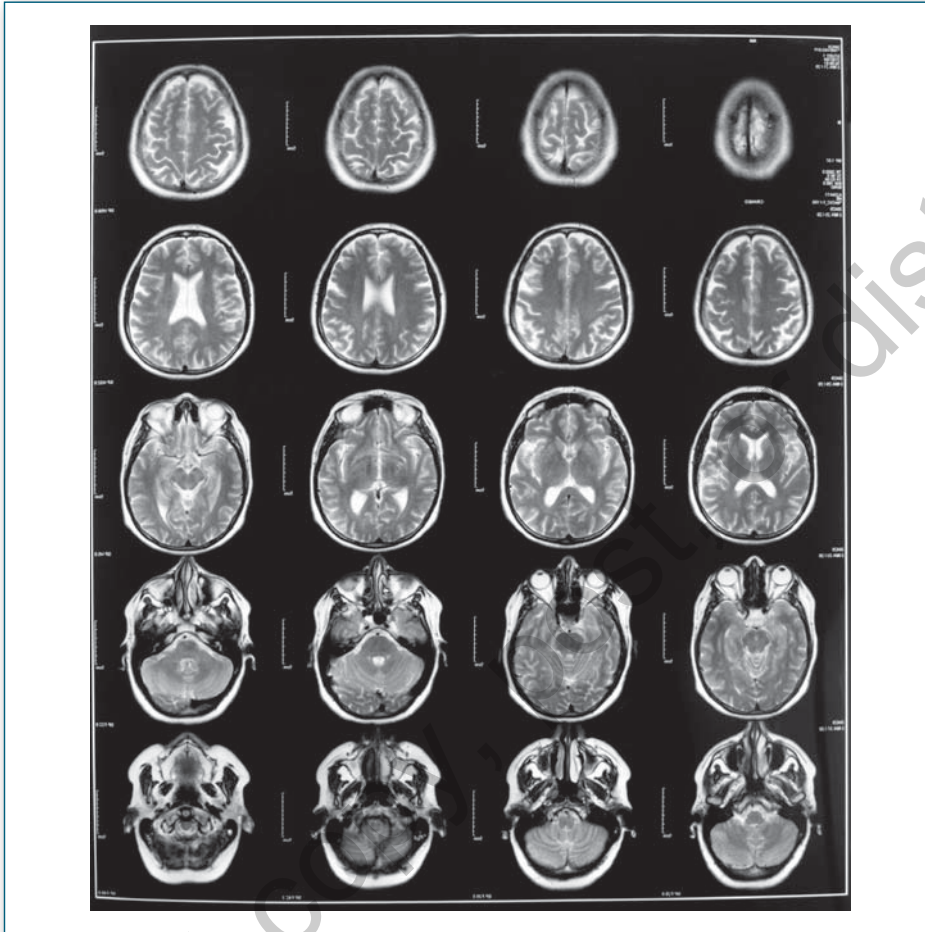
MRI is an acronym for *magnetic resonance imaging*. Like CAT scans, an MRI provides information about neuroanatomy. Unlike CAT scans, however, an MRI requires no exposure to radiation and often permits clearer pictures, as you can see in Figure 3.9, which shows an MRI scan of a brain.

Someone undergoing an MRI typically lies inside a tunnel-like structure that surrounds the person with a strong magnetic field. Radio waves are directed at whatever body structure is being scanned, causing the centers of hydrogen atoms in those structures to align themselves in predictable ways. Computers collate information about how the atoms are aligning and produce a composite three-dimensional image from which any desired cross section can be examined further.

MRI scans are often the technique of choice, as they now produce incredibly clear (relative to PET and CAT scans) images of the brain. However, MRI scans can't be used on some people (those with metal embedded in or attached to their bodies, such as a pacemaker or surgical clips). Because MRIs require people to lie very still in a tube-like machine that often leaves little room for arm movements, people with claustrophobia are also not good candidates for this technique.

MRI scans yield still pictures of the anatomy of a particular region of the brain. As such, they give good information about neuroanatomical

Figure 3.9 MRI scan of a brain—different images show different horizontal “slices” of the brain



SOURCE: © Thinkstockphotos.com

structures of an individual’s brain. Physicians and researchers can use these pictures to pinpoint areas of damage or other abnormality. However, these scans provide relatively static pictures of the parts of a brain and do not give much information about how a brain functions—that is, what areas of the brain show activity when people perform different tasks.

To address this need, other techniques are used, among them **fMRI**, which stands for *functional magnetic resonance imaging* (Nolte, 2009). fMRI uses the fact that blood has magnetic properties. Areas of the brain that are

Courtesy of the Benasich Laboratory, Center for Molecular and Behavioral Neuroscience, Rutgers University



Photo 3.4 This photo shows a baby wearing a so-called *ERP* cap that allows electrical recordings to be taken from the scalp.

active while an individual completes a cognitive task (such as perceiving a stimulus) have an increase in blood flow and thus a higher concentration of oxygen relative to inactive areas of the brain. fMRI picks up on the ratio of hemoglobin to deoxyhemoglobin and generates a picture (usually in color) depicting which areas are especially active. fMRI scans use existing MRI equipment but provide clinicians and investigators with a noninvasive, nonradioactive means of assessing blood flow to various brain regions. fMRI techniques require a certain amount of

cooperation from the experimental participant and thus are not used typically in children younger than about age 4 (Nelson, Moulson, & Richmond, 2006). So we won't be talking about fMRI studies for a few chapters.

The second technique we will discuss involves taking recordings of electrical activity in the brain from sensors attached to the scalp. This recording of so-called **event-related potentials (ERPs)** measures an area of the brain's response to a specific event. Participants are presented with a stimulus, usually either visual or auditory. The recording measures brain activity from the time before the stimulus is presented until some time afterward. The brain waves recorded also have predictable parts, or *components*. That is, the shape of the waveform can vary, depending on whether or not the participant expected the stimulus to occur or was attending to the location in which the stimulus appeared and whether the stimulus is physically different from other recent stimuli. ERPs do not provide the excellent spatial resolution that fMRIs do, but they are entirely noninvasive and very easy to use with infants (Nelson et al., 2006).

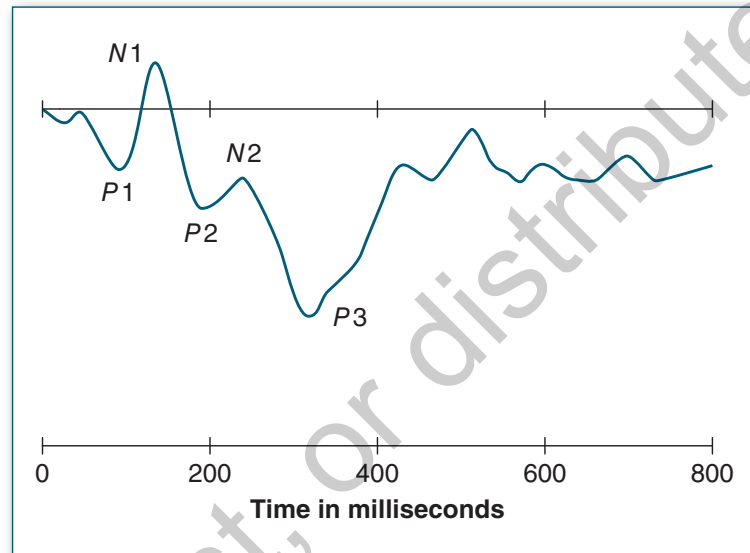
ERP recordings show an averaging of the electrical activity occurring in the brain, relative to the time of presentation of a stimulus. Thus, over a number of trials, the researcher averages the electrical activity in the brain, say, 100 milliseconds after a stimulus presentation. Random electrical activity gets "filtered out" in the averaging, leaving a smooth curve such as the one shown in Figure 3.10. You'll notice that in this figure there are various deflections or curves above the line (known as *N responses*) and also ones below the line (known as *P responses*; Luck, 2005). *P* and *N* are traditionally

used to indicate what researchers call positive-going and negative-going peaks. The number after the *P* or *N* indicates if it is the first, second, or third observed peak. As Luck (2005) summarizes, “The sequence of ERP peaks reflects the flow of information through the brain” (p. 11).

The initial peak (*P1*) happens on just about every trial with every participant—it is often called an “obligatory” response to the stimulus. Changes in the stimulus, such as brightness or loudness, affect the size (amplitude) of the *P1* peak but not whether or not it occurs. In contrast, other deflections such as the *P3* or *N1* often depend upon what kind of processing the participant is doing on the stimulus—they don’t always occur. We’ll talk more about specific peaks when we get to discussions of particular research studies.

Given this brief look at several different research methods used by cognitive developmental researchers, I want to make an important general point: No research method is perfect for all questions. It helps a researcher to have a variety of methods in her toolbox if she wants to be able to investigate a wide variety of questions. Ultimately, the goal is for different research methods to be used in a variety of settings, yielding results that converge on similar answers or explanations. We will see examples of all of the research methods described here throughout the book.

Figure 3.10 Example of an event-related potential (ERP) recording



SOURCE: Luck, Steven J., *An Introduction to the Event-Related Potential Technique*, figure, page 8, © 2005 Massachusetts Institute of Technology, by permission of The MIT Press.

SUMMARY

1. In addition to the specifically formulated theories of cognitive development offered by Piaget and Vygotsky, there are several other theories and frameworks from other areas of psychology that bear on cognitive developmental phenomena.

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2. Information-processing theory describes human cognition by making analogies to computer architecture.
3. The information-processing approach to cognitive development focuses on quantitative differences among children of various ages (e.g., differences in memory capacity, attention span, processing speed, knowledge base, strategies).
4. Classical and instrumental conditioning represent two major forms of learning theory, which holds that a simple set of laws applies to the learning of animals and humans of all ages.
5. Social learning theory, an elaboration of learning theory, holds that children can learn from modeled behavior.
6. Nativism is the idea that at least some knowledge is inborn, or that hardwired structures constrain and direct the acquisition of certain kinds of knowledge. It includes the ideas that some realms of knowledge or processing are innate, hardwired, and special purpose.
7. Understanding the development and functioning of the brain is becoming an increasingly important task for cognitive developmental psychologists. The cerebral cortex can be divided into several lobes, and some cognitive processes have been associated with neural activity in certain areas of these lobes.
8. Theories differ on at least three different dimensions: the nature–nurture dimension, the continuity–discontinuity dimension, and the universal culture-specific dimension.
9. Several different research methods are used by cognitive developmental researchers, and each one has its strengths and weaknesses.
10. Observational studies involve recording responses as they naturally occur.
11. Clinical interviews allow children to provide open-ended responses, which are followed up by specific questions.
12. Correlational studies establish the existence of linear relationships among different dependent measures.
13. Experiments require the investigator to control all influences except the variable of interest.
14. Quasi-experiments are structured like experiments, except that one or more variables (such as age or developmental level) cannot be randomly assigned.
15. Two major techniques to study brain functioning include brain imaging and event-related potential (ERP) recordings.

REVIEW QUESTIONS

1. Describe one possible explanation a psychologist in the information-processing tradition might give to explain one major phenomenon of cognitive development.

2. Explain why information-processing theory is not considered a stage theory of cognitive development.
3. Explain how increases in the knowledge base can be used to account for other cognitive developmental phenomenon.
4. Contrast learning theory with nativist explanations of cognitive development.
5. Describe the major cognitive functions localized in the four cerebral lobes (frontal, parietal, occipital, temporal).
6. Consider the three dimensions of theories of cognitive development. Choose one of the theories we have reviewed, and locate that theory on each of the three dimensions, offering support for your view.
7. Explain the major differences between fMRI scans and ERP recordings to study the developing brain.
8. Explain why, all other things being equal, researchers prefer experiments to other kinds of studies.
9. Which research methods are likely to show the most ecological validity? Why?
10. (Challenging) In this chapter and the last, we have reviewed many major theoretical frameworks and several major research methods used in cognitive developmental psychology. Which pairing of a theoretical framework and research method fits best, and why?

KEY TERMS

Attention Span

Between-Subjects Design

Brain Imaging

CAT Scan

Central Executive

Cerebral Cortex

Classical Conditioning

Clinical Interviews

Cohort Effects

Correlation

Correlational Studies

Ecological Validity

Empiricism

Episodic Buffer

Episodic Memory

Event-Related Potentials (ERPs)

Executive Functioning

Experiment

Experimental Studies

Explicit Memory

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fMRI
Forebrain
Frontal Lobe
Habituation
Hindbrain
Implicit Memory
Information-Processing Theory
Instrumental Conditioning
Language Acquisition Device (LAD)
Long-Term Memory (LTM)
Midbrain
Modularity
MRI
Myelin
Nativism
Neurons
Observational Studies
Occipital Lobe
Operant Conditioning
Parietal Lobe
PET Scan
Phonological Loop
Prefrontal Cortex
Quasi-Experimental Design
Recall Memory
Recognition Memory
Rehearsal
Research Methods
Retrieval
Rule Assessment Approach
Semantic Memory
Short-Term Memory (STM)
Strategies
Temporal Lobe
Visuospatial Sketch Pad
Within-Subjects Design