Cognitive Change: 
Information Processing Approach

Learning Objectives

7.1 Identify the parts of the information processing system and its function over the lifespan.

7.2 Describe developmental changes in infants’ capacities for attention, memory, and thought.

7.3 Describe developmental changes in children’s capacities for attention, memory, and thought.

7.4 Explain how advances in brain development during adolescence influence memory, metacognition, and scientific reasoning.

7.5 Compare patterns of change in working memory, long-term memory, problem-solving capacities, and wisdom in adulthood.

Digital Resources

- Executive Function
- The Central Executive
- Infant Habitation
- Infant Information Processing
- Brain Injury and Theory of Mind
- A Structure for Thinking
- Thinking and Decision Making in Adolescence
- Risk Taking or Exploration?
- The Reminiscence Bump
- With Age Comes Wisdom

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“Say, ‘RED!’ whenever you see a red car,” instructed Dad as he drove Tyler and Shana to school. “Red!” Dad called out as they passed a red minivan. A few minutes later, 3-year-old Tyler shouted, “Red!” “I don’t see a red car. Tyler, you have to wait until you see a red car; then you can say, ‘Red,'” instructed his older sister. After carefully scanning the roadway, Shana spotted a red car. “Red!” she shouted and turned to Tyler, “See?” This silly game can make a car trip pass more quickly, but it also tells us about people’s cognitive development. Advances in information processing skills, such as attention and working memory, contribute to success in this game.

Whereas the cognitive developmental approaches presented in Chapter 6 describe cognitive changes as discontinuous in nature, information processing theorists argue that people’s thinking undergoes more gradual and continuous change. From this perspective, our judgment becomes more complex and our reasoning faster and more efficient because of improvements in information processing. In this chapter, we examine the information processing system over the lifespan.
THE INFORMATION PROCESSING SYSTEM

LO 7.1 Identify the parts of the information processing system and its function over the lifespan.

From an information processing perspective, the mind is composed of three mental stores: sensory memory, working memory, and long-term memory. From early infancy to mature adulthood, information moves through these stores, and we use these three stores to manipulate and store it.

**Sensory memory**, sometimes called the *sensory register*, is the first step in getting information into the mind; it holds incoming sensory information in its original form. For example, look at this page, then close your eyes. Did you “see” the page for a fraction of a second after you closed your eyes? That image, or icon, represents your sensory memory. Information fades from sensory memory quickly if it is not processed, even as quickly as fractions of a second. Newborn infants display sensory memory, although it is much shorter in duration than adults’ memory (Cheour et al., 2002). As a great deal of information is taken in and rapidly moves through sensory memory, much of it is discarded—but when we direct our attention or awareness to information, it passes to the next part of the information processing system, working memory.

**Working memory**, sometimes called short-term memory, holds and processes information that is being “worked on” in some way: manipulated (considered, comprehended), encoded (transformed into a memory), or retrieved (recalled). Working memory is responsible for maintaining and processing information used in many complex cognitive tasks (Gathercole, 1998). All of your thoughts—that is, all conscious mental activity—occur within working memory. For example, reading this paragraph, remembering assignments, and considering how this material applies to your own experience taps your working memory. Just as your thoughts are constantly changing, so are the contents of working memory. A core assumption of the information processing approach is the idea of limited capacity. We can only hold on to so much information in mind, or in working memory, for long. With development, we get better at retaining information in working memory and use it in more efficient ways.

An important part of working memory is the **central executive**, a control processor that directs the flow of information and regulates cognitive activities such as attention, action, and problem solving. The central executive determines what is important to attend to, combines new information with information already in working memory, and selects and applies strategies for manipulating the information in order to understand it, make decisions, and solve problems (Andersson, 2008; Baddeley, 1986, 1996). Collectively, these cognitive activities are known as **executive function**.

As information is manipulated in working memory it becomes more likely that it will enter long-term memory, the third mental store. **Long-term memory** is an unlimited store that holds information indefinitely. Information is not manipulated or processed in long-term memory; it is simply stored until it is retrieved to manipulate in working memory (e.g., remembering events and thinking about them). With development we amass a great deal of information, organize it in increasingly sophisticated ways, and encode and retrieve it more efficiently and with less effort.

We are born with the ability to take in, store, and manipulate information through our sensory, working, and long-term memory. The structure of the information processing system remains the same throughout the lifespan (see Figure 7.1). With development, we get better at moving information through our cognitive system in ways that allow us to adapt to our world. We can process more
information, retain more information, and do so more quickly and efficiently. We are born with a functioning information processing system, and it develops rapidly and very early in life.

**Thinking in Context 7.1**

Compare the information processing model with Piaget’s cognitive developmental perspective. How are the perspectives similar and different?

## INFORMATION PROCESSING IN INFANCY

**LO 7.2 Describe developmental changes in infants’ capacities for attention, memory, and thought.**

Information processing theorists describe cognition as a set of interrelated components that enable people to process information—to notice, take in, manipulate, store, and retrieve it. Newborns are ready to learn and adapt to their world because, like children and adults, they are born information processors.

### ATTENTION IN INFANTS

Attention refers to the ability to direct one’s awareness. Infant attention is often studied using the same methods used to learn about their visual perception (see Chapter 4). Preferential looking procedures (measuring and comparing the length of time infants look at two stimuli) and habituation procedures (measuring the length of time it takes infants to habituate or show a reduction in looking time to nonchanging stimuli) are used to study infants’ attention to visual stimuli such as geometric patterns (Oakes, 2010; Richards, 2010, 2011). Infants show more attentiveness to dynamic stimuli—stimuli that change over time—than to static, unchanging stimuli (Reynolds, Zhang, & Guy, 2013; Richards, 2010).

By around 10 weeks of age infants show gains in attention. As infants’ capacities for attention increase, so do their preferences for complex stimuli. For example, in one experiment, 3- to 13-month-old infants were shown displays that included a range of static and moving stimuli (Courage, Reynolds, & Richards, 2006). From about 6½ months of age, infants’ looking time varied with stimulus complexity, decreasing for simple stimuli such as dot patterns, increasing slightly for complex stimuli such as faces, and increasing more for very complex stimuli such as video clips (Courage et al., 2006).

Recently, researchers have begun using brain imaging techniques to measure infants’ brain activity because the development of infant attention is thought to be closely related to neurological development in the areas underlying attentional control (Reynolds, 2015). In response to tasks that challenge attention, infants show activity in the frontal cortex (used for thinking and planning) that is diffuse (widely spread) at 5.5 months of age, but more specific or localized by 7.5 months of age (Richards, 2010). The ability to focus and switch attention is critical for selecting information to process in working memory and is influenced by neurological development, including advances in myelination (Qiu, Mori, & Miller, 2015). Important developments in attention occur over the course of infancy and continue throughout childhood.

### MEMORY IN INFANTS

Habituation studies measuring looking time and brain activity demonstrate that neonates can recall visual and auditory stimuli (Muenssinger et al., 2013; Streri, Hevia, Izard, & Coubart, 2013). When infants habituate to a
stimulus and are shown it again after a delay, more rapid habituation on the second exposure indicates that they remember the stimulus (Oakes, 2010). Classic habituation studies have shown that by 3 months of age, infants can remember a visual stimulus for 24 hours, and by the time they are 1 year old, they can retain such memories for several days or even weeks (Fagan, 1973; Martin, 1975).

Infants can also remember motor activities. In one study, 2- to 3-month-old infants were taught to kick their foot, which was tied to a mobile with a ribbon, to make the mobile move (see Figure 7.2). One week later, when the infants were reattached to the mobile they kicked vigorously, indicating their memory of the first occasion. The infants would kick even 4 weeks later if the experimenter gave the mobile a shake to remind them of its movement (Rovee-Collier & Bhatt, 1993; Rovee-Collier, 1999). Infants have basic memory capacities common to children and adults (Rose, Feldman, Jankowski, & Van Rossem, 2011), but they are most likely to remember events when they take place in familiar contexts and when the infants are actively engaged (Learmonth, Lambeth, & Rovee-Collier, 2004).

Emotional engagement also enhances infants’ memory. Infants are more likely to remember events that are associated with emotions. For example, the still-face interaction paradigm is an experimental task in which an infant interacts with an adult who first engages in normal social interaction and then suddenly lets his or her face become still and expressionless, not responsive to the infant’s actions (Tronick, Als, Adamson, Wise, & Brazelton, 1978). Infants usually respond to the adult’s still face with brief smiles followed by negative facial expressions, crying, looking away, thumb sucking, and other indications of emotional distress (Shapiro, Fagen, Prigot, Carroll, & Shalan, 1998; Weinberg & Tronick, 1994, 1996). In one study, 5-month-old infants who were exposed to the still face demonstrated recall over a year later, at 20 months of age, by looking less at the woman who appeared in the still-face paradigm than at two other women whom the infants had never previously seen (Bornstein, Arterberry, & Mash, 2004). These lines of research suggest that memory improves over the course of infancy, but even young infants are likely to recall events in which they are actively engaged, that take place in familiar surroundings, and that are emotionally salient (Courage & Cowan, 2009; Learmonth et al., 2004).

**INFANTS’ THINKING**

In infants’ eyes, all of the world is new—“one great blooming, buzzing confusion,” in the famous phrase of 19th-century psychologist William James (1890). How do infants think about and make sense of the world? As infants are bombarded with a multitude of stimuli, encountering countless new objects, people, and events, they form concepts by naturally grouping stimuli into classes or categories. **Categorization**, grouping different stimuli from a common class, is an adaptive mental process that allows for organized storage of information in memory, efficient retrieval of that information, and the capacity to respond with familiarity to new stimuli from a common class.

**Categorization**  An adaptive mental process in which objects are grouped into conceptual categories, allowing for organized storage of information in memory, efficient retrieval of that information, and the capacity to respond with familiarity to new stimuli from a common class.
Just as in studying perception and attention, developmental researchers must rely on basic learning capacities, such as habituation, to study how infants categorize objects. For example, infants are shown a series of stimuli belonging to one category (e.g., fruit: apples and oranges), and then are presented with a new stimulus of the same category (e.g., a pear or a lemon) and a stimulus of a different category (e.g., a cat or a horse). If an infant dishabituates, or shows renewed interest by looking longer at the new stimulus (e.g., cat), it suggests that he or she perceives it as belonging to a different category from that of previously encountered stimuli (Cohen & Cashon, 2006). Using this method, researchers have learned that 3-month-old infants categorize pictures of dogs as different from cats based on perceived differences in facial features (Quinn, Eimas, & Rosenkrantz, 1993).

Infants' earliest categories are based on the perceived similarity of objects (Rakison & Butterworth, 1998). By 4 months, infants can form categories based on perceptual properties, grouping objects that are similar in appearance including shape, size, and color (Colombo et al., 1990; Quinn & Eimas, 1996; Rakison & Butterworth, 1998). As early as 7 months of age, infants use conceptual categories based on perceived function and behavior (Mandler, 2000, 2004). Moreover, patterns in 6- to 7-month-old infants’ brain waves correspond to their identification of novel and familiar categories (Quinn, Doran, Reiss, & Hoffman, 2010). Seven- to 12-month-old infants use many categories to organize objects, such as food, furniture, birds, animals, vehicles, kitchen utensils, and more, based on perceptual similarity and perceived function and behavior (Mandler & McDonough, 1993, 1998; Oakes, Coppage, & Dingel, 1997).

Researchers also use sequential touching tasks to study the conceptual categories that older infants create (Mandler, Fivush, & Reznick, 1987). Infants are presented with a collection of objects from two categories (e.g., four animals and four vehicles) and their patterns of touching are recorded. If the infants recognize a categorical distinction among the objects, they touch those from within a category in succession more than would be

**TABLE 7.1 • Changes in Information Processing Skills During Infancy**

| Attention | Increases steadily over infancy  
|           | From birth infants attend more to dynamic than static stimuli  
|           | During the second half of their first year infants attend more to complex stimuli such as faces and video clips  
|           | Linked with diffuse frontal lobe activity in young infants and localized frontal lobe activity by 7.5 months of age  
|           | Individual differences appear at all ages and are stable over time  
|           | Associated with performance on visual recognition memory tasks |
| Memory    | Improves with age  
|           | 3-month-old infants can remember a visual stimulus for 24 hours  
|           | By the end of the first year infants can remember a visual stimulus for several days or even weeks  
|           | Infants are most likely to remember events in familiar, engaging, and emotionally salient contexts |
| Thinking  | Infants’ first concepts are based on perceived similarity  
|           | By 4 months infants can form categories based on perceptual properties such as shape, size, and color  
|           | By 6 to 7 months infants’ brain waves correspond to their identification of novel and familiar categories  
|           | 7- to 12-month-old infants can organize objects such as food, furniture, animals, and kitchen utensils, based on perceived function and behavior  
|           | 12- to 30-month-old infants categorize objects first at a global level and then at more specific levels  
|           | Infants categorize objects at more global and inclusive levels (such as motor vehicles) before more specific and less inclusive levels (such as cars, trucks, construction equipment)  
|           | The use of categories improves memory efficiency |
expected by chance (Bornstein & Arterberry, 2010). Research using sequential touching procedures has shown that 12- to 30-month-old toddlers organize objects first at a global level and then at more specific levels. They categorize at more inclusive levels (e.g., animals or vehicles) before less inclusive levels (e.g., types of animals or vehicles) and before even less inclusive levels (e.g., specific animals or vehicles; Bornstein & Arterberry, 2010). Infants’ and toddlers’ everyday experiences and exploration contribute to their growing capacity to recognize commonalities among objects, group them in meaningful ways, and use these concepts to think and solve problems (Mandler, 2004; Oakes & Madole, 2003). Recognizing categories is a way of organizing information that allows for more efficient thinking, including storage and retrieval of information in memory. Therefore, advances in categorization are critical to cognitive development.

As shown in Table 7.1, information processing capacities, such as attention, memory, and categorization skill, show continuous change over the first three years of life (Rose, Feldman, & Jankowski, 2009). Infants get better at attending to the world around them, remembering what they encounter, and organizing and making sense of what they learn. Infants’ emerging cognitive capacities influence all aspects of their development and functioning.

Thinking in Context 7.2

1. What are some of the challenges in studying how infants think and what they know? How do researchers address these issues? Can you identify challenges to information processing researchers’ methods, findings, or conclusions?

2. Given what we know about infants’ capacities for attention, memory, and thinking, what kinds of toys and activities would you recommend to caregivers who want to entertain infants while promoting their development?

Information Processing in Childhood

LO 7.3 Describe developmental changes in children’s capacities for attention, memory, and thought.

“If you’re finished, put your head down on your desk and rest for a moment,” Mrs. McCalvert advised. She was surprised to see that three-quarters of her students immediately put their heads down. “They are getting quicker and quicker! I guess next time I’ll assign more challenging problems,” she thought to herself. Information processing theorists would agree with Mrs. McCalvert’s observation because the information processing perspective describes development as entailing changes in the efficiency of cognition rather than qualitative changes in reasoning. It is easy to observe that school-age children can take in more information, process it more accurately and quickly, and retain it more effectively than younger children. But what are the changes that enable them to do this? They are better able to determine what information is important, attend to it, and use their understanding of how memory works to choose among strategies to retain information more effectively. Sensory memory does not appear to change much with development: Five-year-old children demonstrate similar capacities and performance as adults (Cowan, Nugent, Elliott, Ponomarev, & Saults, 1999; Kail & Reese, 2002). Yet other information processing abilities, such as attention, advance steadily throughout childhood.

Attention in Children

The ability to sustain one’s attention improves from early childhood through the early childhood years, but young children often struggle with selective attention. **Selective attention**
refers to the ability to systematically deploy one’s attention, focusing on relevant information and ignoring distractors. Young children do not search thoroughly when asked to compare detailed pictures and explain what’s missing from one. They have trouble focusing on one stimulus and switching their attention to compare it with other stimuli (Hanania & Smith, 2010). For example, young children who sort cards according to one dimension, such as color, may later be unable to successfully switch to a different sorting criteria (Honominchl & Zhe, 2011). Young children become better at planning, considering the steps needed to complete a particular act, and focusing their attention (Rueda, 2013). Preschoolers can create and abide by a plan to complete tasks that are familiar and not too complex, such as systematically searching for a lost object in a yard (Wellman, Somerville, & Haake, 1979). But they have difficulty with more complex tasks. Young children have difficulty deciding where to begin and how to proceed to complete a task in an orderly way. When they plan, young children often skip important steps (Friedman & Scholnick, 1987; Ruff & Rothbart, 1996).

Researchers study selective attention using tasks that require children to ignore distractors. For example, children might be asked to watch a computer screen while random numbers flash on and off and then press a button whenever a particular sequence of numbers (such as 7 and then 2) appear. Between ages 6 and 10, children show rapid gains in their ability to control their attention and deploy selective attention, focusing on relevant information and ignoring what is irrelevant (Gómez-Pérez & Ostrosky-Solís, 2006). Selective attention continues to improve in adolescence. Children’s success in tasks measuring the ability to direct and control attention are influenced by developments in working memory, and attention, in turn, exerts an influence on working memory (Bertrand & Camos, 2015; Baddeley, 2012; Nelson Cowan, Ricker, Clark, Hinrichs, & Glass, 2015).

WORKING MEMORY AND EXECUTIVE FUNCTION IN CHILDREN

An important part of working memory is the central executive, which regulates cognitive activities that comprise executive function, such as attention, action, and problem solving. Specifically, the central executive is responsible for (1) coordinating performance on two separate tasks or operations, such as both storing and processing information at the same time; (2) quickly switching between tasks, such as manipulating and storing information; (3) selectively attending to specific information and ignoring irrelevant information; and (4) retrieving information from long-term memory (Baddeley, 1996, 2012). Central executive function is thought to have a biological basis because the cognitive activities controlled by the central executive are associated with certain regions of the cortex, specifically several areas of the frontal lobe and part of the parietal lobe (Collette & Van der Linden, 2002; Petersen & Posner, 2012).

Steady increases in executive function and working memory occur throughout childhood, from 3 years of age through adolescence, and are responsible for the cognitive developmental changes seen during childhood (Brocki & Bohlin, 2004; Freier, Cooper, & Mareschal, 2015). For example, during the elementary school years working memory capacity—how much material can be held—improves substantially (Kail & Park, 1994; Schneider & Pressley, 2013). One study demonstrated that between ages 6 and 7 children begin to use strategies to complete memory tasks, permitting the 7-year-old children to show greater recall than the 6-year-old children (Camos & Barrouillet, 2011). Yet even at age 8, children are able to retain only about half the number of items that adults can (Kharitonova, Winter, & Sheridan, 2015). However, changes in performance on working
memory tasks are influenced by context. Research with Australian children suggests that the amount of schooling is a better predictor of improvements in working memory than is chronological age (Roberts et al., 2015). High-quality relations with teachers are associated with higher scores on working memory tasks during elementary school (de Wilde, Koot, & van Lier, 2016).

**Memory Strategies**

One reason why young children perform poorly in recall tasks is that they are not very effective at using memory strategies, which are cognitive activities that make us more likely to remember. Common memory strategies are rehearsal, organization, and elaboration. Rehearsal refers to systematically repeating information in order to retain it in working memory. A child may say a phone number over and over to not forget it before writing it down. Organization refers to categorizing or chunking items to remember by grouping it by theme or type, such as animals, flowers, and furniture. When memorizing a list of words, a child might organize them into meaningful groups or chunks—foods, animals, objects, and so forth. Growth in working memory is partially attributed to an increase in the number of chunks children can retain with age (Cowan et al., 2010). Children start to use organization soon after they begin using rehearsal. A third strategy, elaboration, entails creating an imagined scene or story to link the material to be remembered. To remember to buy bread, milk, and butter, for example, a child might imagine a slice of buttered bread balancing on a glass of milk. It is not until the later school years that children use elaboration without prompting and apply it to a variety of tasks (Camos & Barrouillet, 2011). As children make use of memory strategies, their recall improves dramatically.

Preschool-age children can be taught strategies, but they generally do not transfer their learning and apply it to new tasks (Titz & Karbach, 2014; Gathercole, Adams, & Hitch, 1994; Miller & Seier, 1994). This utilization deficiency seems to occur because of their limited working memories. They cannot apply the strategy at the same time as they have to retain both the material to be learned and the strategy to be used. Instead, new information competes with the information the child is attempting to recall. Unlike older children and adults, preschoolers are often are unable to inhibit the new information to successfully recall older information (Aslan & Bäuml, 2010). Children do not spontaneously and reliably apply rehearsal until after the first grade (Bjorklund & Douglas, 1997; Schneider & Bjorklund, 1992), and they do not start to apply strategies consistently and effectively until middle childhood (Kron-Sperl, Schneider, & Hasselhorn, 2008). Advances in executive function, working memory, and attention predict strategy use (Stone, Blumberg, Blair, & Cancelli, 2016). Effective strategy use requires that children attend to a problem, keep it in mind, choose among strategies, and devise and implement a plan—a complex set of cognitive activities.

Throughout middle childhood, children learn more strategies and get better at selecting them, modifying them to suit the task at hand, and using them more effectively. All of these memory skills contribute to advances in cognitive performance (Bjorklund, 2013; Imbo & Vandierendonck, 2007). For example, 5th-grade students who use more complex memory strategies are more successful in delayed recall tasks in which they are asked to read a passage and then recall it after a delay (Jonsson, Wiklund-Hörnqvist, Nyroos, & Börjesson, 2014). With development children's strategy use becomes more efficient. They use more than one strategy during a given task and choose different strategies for different tasks (Justice, Baker-Ward, Gupta, & Jannings, 1997; Lehmann & Hasselhorn, 2007).

**Knowledge**

Throughout childhood, children acquire increasing amounts of information, which they naturally organize in meaningful ways. As children learn more about a topic, their knowledge structures become more elaborate and organized, while the information
becomes more familiar and meaningful and easier to store and recall. It is easier to recall new information about topics with which we are already familiar, and existing knowledge about a topic makes it easier to learn more about that topic (Ericsson & Moxley, 2013). During middle childhood, children develop vast knowledge bases and organize information into elaborate hierarchical networks that enable them to apply strategies in more complex ways and remember more material than ever before—and more easily than ever before (Schneider & Pressley, 2013). For example, 4th-grade students who are experts at soccer show better recall of a list of soccer-related items than do students who are soccer novices, but the groups of children do not differ on the non-soccer-related items (Schneider & Bjorklund, 1992). The soccer experts tended to organize the lists of soccer items into categories; their knowledge helped them to organize the soccer-related information with little effort, using fewer resources on organization and permitting the use of more working memory for problem solving and reasoning. Novices, in contrast, lacked a knowledge base to aid their attempts at organization.

School-age children demonstrate increasingly sophisticated performance in a range of skills such as language comprehension, reading, and mathematics ability (Mazzocco & Kover, 2007). Improvements in memory, attention, and processing speed are possible because of brain development, particularly myelination and pruning. Neural systems for visuospatial working memory, auditory working memory, and response inhibition differentiate, dividing into separate parts to enable faster and more efficient processing of these critical cognitive functions (Tsujimoto, Kuwajima, & Sawaguchi, 2007). Children become quicker at matching pictures and recalling spatial information, among other tasks (Gathercole & Hitch, 1993). Between ages 3 and 7, children show increasing prefrontal cortex engagement while completing tasks that measure working memory (Perman, Huppert, & Luna, 2016). Areas of the prefrontal cortex become more specialized in late childhood (Farber & Beteleva, 2011). Development of the prefrontal cortex leads to advances in response inhibition, the ability to withhold a behavioral response inappropriate in the current context, and this increases children's capacity for self-regulation—controlling their thought and behavior—which, in turn, contributes to advances in metacognition (Tsujimoto et al., 2007).

Over the course of childhood children get better at using strategies in their daily life. However, the strategies that children use to tackle cognitive tasks vary with culture. In fact, daily tasks themselves vary with our cultural context. Children in Western cultures receive lots of experience with tasks that require them to recall bits of information and thereby develop considerable expertise in the use of memory strategies such as rehearsal, organization, and elaboration. On the other hand, research shows that people in nonwestern cultures with no formal schooling do not use or benefit from instruction in memory strategies such as rehearsal (Rogoff & Chavajay, 1995). Instead, they refine memory skills that are adaptive to their way of life. For example, they may rely on spatial cues for memory, such as when recalling items within a three-dimensional miniature scene. Australian aboriginal and Guatemalan Mayan children perform better at these tasks than do children from Western cultures (Rogoff & Waddell, 1982). Culture and contextual demands influence the cognitive strategies that we learn and prefer, as well as how we use our information processing system to gather, manipulate, and store knowledge. Children of all cultures amass a great deal of information and as they get older, they organize it in more sophisticated ways, and encode and retrieve it more efficiently and with less effort.
LONG-TERM MEMORY IN CHILDREN

Unlike infants, young children can speak and follow directions, and these abilities make it easier to study their memory skills. **Episodic memory** refers to memory for events and information acquired during those events (Roediger & Marsh, 2003; Tulving, 2002). For example, a researcher might study episodic memory by asking a child, “Where did you go on vacation?” or “Remember the pictures I showed you yesterday?” Most laboratory studies of memory examine episodic memory, such as memory for specific information, for scripts, and for personal experiences.

**Memory for Information**

Shana turns over one card and exclaims, “I’ve seen this one before. I know where it is!” She quickly selects its duplicate by turning over a second card from an array of cards. Shana recognizes a card she has seen before and recalls its location. Children’s memory for specific information, such as the location of items, lists of words or numbers, and directions, can be studied using tasks that examine recognition memory and recall memory. **Recognition memory**, the ability to recognize a stimulus one has encountered before, is nearly perfect in 4- and 5-year-old children, but they are much less proficient in **recall memory**, the ability to generate a memory of a stimulus encountered before without seeing it again (Myers & Perlmutter, 2014). Two-year-olds can typically recall just one or two items, whereas 4-year-olds can recall three or four items (Perlmutter, 1984).

**Memory for Scripts**

Young children remember familiar repeated everyday experiences, like the process of eating dinner, taking a bath, or going to nursery school or preschool, as **scripts**, or descriptions of what occurs in a particular situation. When young children begin to use scripts, they remember only the main details. A 3-year-old might describe a trip to a restaurant as follows: “You go in, eat, then pay.” These early scripts include only a few acts but usually are recalled in the correct order (Bauer, 1996). As children grow older and gain cognitive competence, scripts become more elaborate. Consider a 5-year-old child’s explanation of a trip to a restaurant: “You go in, you can sit at a booth or a table, then you tell the waitress what you want, you eat, if you want dessert, you can have some, then you go pay, and go home” (Hudson, Fivush, & Kuebli, 1992). Scripts help children understand repeated events, serve as an organization tool, and help children predict what to expect in the future. However, scripts may inhibit memory for new details. For example, in one laboratory study children were presented with a script of the same series of events repeated in order multiple times as well as a single alternative event. Preschoolers were less likely than older children to spontaneously recall and provide a detailed account of the event (Brubacher, Glisic, Roberts, & Powell, 2011).

**Autobiographical Memory**

**Autobiographical memory** refers to memory of personally meaningful events that took place at a specific time and place in one’s past (Nelson & Fivush, 2004). Most people have no memories prior to age 3, a phenomenon known as **infantile amnesia** (Howe & Courage, 1993). Yet, as discussed earlier in this chapter, infants
demonstrate recall. Why, then, do we not retain memories from infancy? Just as language development helps us learn more complicated ways of thinking and communicating, it also helps us learn how to use our memory (Fivush & Nelson, 2004). Autobiographical memory is thought to serve a social function, as children learn to remember through interactions with adults and they construct autobiographical memories to share with others (Nelson & Fivush, 2004).

Autobiographical memory develops steadily from the preschool years through adolescence, and it is accompanied by increases in the length, richness, and complexity of recall memory (Fivush, 2011; Pipe, Lamb, Orbach, & Esplin, 2004). Young children report fewer memories for specific events than do older children and adults (Baker-Ward, Gordon, Ornstein, Larus, & Clubb, 1993). But by age 3, they are able to retrieve and report specific memories, especially those that have personal significance.

Children’s Suggestibility

The accuracy of children’s memory, especially their vulnerability to suggestion, is an important topic because children as young as 3 years of age have been called upon to relate their memories of events that they have experienced or witnessed, including abuse, maltreatment, and domestic violence (Flavell, Friedrich, & Hoyt, 1970; Kail & Park, 1992; Nelson, 1993). How suggestible are young children? Can we trust their memories?

Research suggests that repeated questioning may increase suggestibility in children (La Rooy, Lamb, & Pipe, 2011). For example, in one study, preschoolers were questioned every week about events that had either happened or not happened to them; by the 11th week, nearly two-thirds of the children falsely reported having experienced an event (Ceci et al., 1994). Preschool-age children may be more vulnerable to suggestion about many topics, including those containing sexual themes, than either school-age children or adults (Gordon, Baker-Ward, & Ornstein, 2001; Principe, Ornstein, Baker-Ward, & Gordon, 2000; Rocha, 2013). When children were asked if they could remember several events, including a fictitious instance of getting their finger caught in a mousetrap, almost none of them initially recalled these events. However, after repeated suggestive questioning, more than half of 3- and 4-year-olds and two-fifths of 5- and 6-year-olds said they recalled these events—often vividly (Poole & White, 1991, 1993).

Young children’s natural trust in others may enhance their suggestibility (Jaswal, 2010). In one study, 3-year-olds who received misleading verbal and visual information from an experimenter about a sticker’s location continued to search in the wrong, suggested, location despite no success (Jaswal, 2010). In another study, 3- to 5-year-old children watched as an adult hid a toy in one location, then told the children that the toy was in a different location. When retrieving the toy, 4- and 5-year-olds relied on what they had seen and disregarded the adult’s false statements, but 3-year-olds deferred to what the adult had said, despite what they had directly observed (Ma & Ganea, 2010).

In some cases children can resist suggestion. For example, in one study, 4- and 7-year-old children either played games with an adult confederate (e.g., dressing up in costumes, playing tickle, being photographed) or merely watched the games (Ceci & Bruck, 1998). Eleven days later, each child was interviewed by an adult who included misleading questions that were often followed up with suggestions relevant to child abuse. Even the 4-year-olds resisted the false suggestions about child abuse.

Children are more vulnerable than adults, but adults are not entirely resistant to suggestion. Like children, adults who are exposed to information that is misleading or inconsistent with their experiences are more likely to perform poorly during memory interviews—and repeated questioning has a similar effect on performance (Ceci & Friedman, 2000; Fivush, 1993; Wysman, Scoboria, Gawrylowicz, & Memon, 2014).

What Do You Think?

Suppose you need to question a preschool child about an event. How would you maximize the likelihood of the child’s giving an accurate account of what occurred?
are repeated, or are highly stressful (Fivush, 1993; Nuttall, 2014). For example, in one study, children who were at least 26 months old at the time of an accidental injury and visit to the emergency room accurately recalled the details of these experiences even after a 2-year delay (Goodman, Rudy, Bottoms, & Aman, 1990). Eight-year-old children have been found to accurately remember events that occurred when they were as young as 3½ years of age (Goodman & Aman, 1990).

Events that are unique or new, such as a trip to the circus, are better recalled; 3-year-old children will recall them for a year or longer (Fivush, Hudson, & Nelson, 1983). Frequent events, however, tend to blur together. Young children are better at remembering things they did than things they simply watched. For example, one study examined 5-year-old children’s recall of an event they either observed, were told about, or experienced. A few days later the children who actually experienced the event were more likely to recall details in a more accurate and organized way, and to require fewer prompts (Murachver, Pipe, Gordon, Owens, & Fivush, 1996).

The way adults talk with the child about a shared experience can influence how well the child will remember it (Haden & Fivush, 1996; Reese & Fivush, 1993). Parents with an elaborative conversational style discuss new aspects of an experience, provide more information to guide a child through a mutually rewarding conversation, and affirm the child’s responses. Three-year-olds of parents who use an elaborative style engage in longer conversations about events, remember more details, and tend to remember the events better at age 5 and 6 (Boland, Haden, & Ornstein, 2003; Fivush, 2011; Reese, Haden, & Fivush, 1993).

Overall, memory improves steadily between ages 4 and 10, with accelerated rates between 5 and 7 (Myers & Perlmutter, 2014; Riggins, 2014). Young children lack knowledge about how to conduct memory searches, determine what is important to recall, and structure narrative accounts of events (Leichtman & Ceci, 1995). They tend to forget information more quickly than older children, rely more on verbatim memory, and confuse different sources of event information (Ackil & Zaragoza, 1995; Levine, Stein, & Liwag, 1999; Warren & Lane, 1995). Young children can have largely accurate memories, but they can also tell tall tales, make errors, and succumb to misleading questions. Their ability to remember events can be influenced by information and experiences that may interfere with accurate recall: conversations with parents and adults, exposure to media, and sometimes intentional suggestions. Children’s vulnerability to suggestion is discussed in the Applying Developmental Science feature. Between ages 5 and 7, children get better at linking memory and source and contextual details (Riggins, 2014). Older children can conduct internal memory searches, easily recreate images in their heads, think of information similar to the to-be-remembered event, and organize and present the recalled information in a systematic manner (Ceci, Huffman, Smith, & Loftus, 1994). During the school years, children become more capable of providing detailed and spontaneous memory descriptions; their use of mnemonic strategies increases and they become aware of the needs of listeners.

**CHILDREN’S THINKING AND METACOGNITION**

Over the childhood years thinking becomes more complex. In particular, children become increasingly aware of the process of thinking and of their own thoughts. **Theory of mind** refers to children’s awareness of their own and other people’s mental processes. This awareness of the mind can be considered under the broader concept of **metacognition** or knowledge of how the mind works and the ability to control the mind (Lockl & Schneider, 2007). Let’s explore these concepts.

**Theory of Mind**

Young children’s understanding of the mind grows and changes between the ages of 2 and 5 (Bower, 1993; Flavell, Green, & Flavell, 1995). For example, 3-year-old children
understand the difference between thinking about a cookie and having a cookie. They know that having a cookie means that one can touch, eat, or share it, but thinking about a cookie does not permit such actions (Astington, 1993). Young children also understand that a child who wants a cookie will be happy upon receiving one and sad upon not having one (Moses, Coon, & Wusinich, 2000; Wellman, Phillips, & Rodriguez, 2000). Similarly, they understand that a child who believes he is having hot oatmeal for breakfast will be surprised upon receiving cold spaghetti (Wellman & Banerjee, 1991). Theory of mind is commonly assessed by examining children's abilities to understand that people can hold different beliefs about an object or event.

Three-year-old children tend to perform poorly on false-belief tasks, which are tasks that require them to understand that someone does not share their knowledge. In a classic false-belief task, children who are presented with a Band-Aid box that contains pencils rather than Band-Aids will show surprise, but they tend to believe that other children will share their knowledge and expect the Band-Aid box to hold pencils (see Figure 7.3; Flavell, 1993; Flavell et al., 1995; Jenkins & Astington, 1996). The children do not yet understand that the other children hold different beliefs. In addition, the children will claim that they knew all along that the Band-Aid box contained pencils (Birch, 2005). They confuse their present knowledge with their memories for prior knowledge and have difficulty remembering ever having believed something that contradicts their current view (Bernstein, Atance, Meltzoff, & Loftus, 2007; Mitchell & Kikuno, 2000).

Three-year-old children show a pattern of false-belief errors that are robust across procedures and cultures (Wellman, Cross, & Watson, 2001; Wellman & Liu, 2004). However, some researchers assert that young children are much more competent than they appear because research using preferential looking and habituation tasks has suggested an understanding of false belief as early as 15 months of age (Buttelmann, Over, Carpenter, & Tomasello, 2014; Onishi & Baillargeon, 2005). Similar to arguments regarding object permanence in infancy and egocentrism in early childhood (see Chapter 6), it may be that children understand the concept (the Band-Aid box contains pencils, not bandages) but may have difficulty communicating their understanding to the researcher (Helming, Strickland, & Jacob, 2014). Yet other researchers counter that false-belief findings with infants reflect perceptual preferences, that is, a desire to look at one object over another, not theory of mind (Heyes, 2014). Indeed, the research to date suggests that theory of mind as evidenced by false-belief tasks emerges at about 3 years of age and shifts reliably between 3 and 4 years of age (Apperley, Samson, Humphreys, & Humphreys, 2009). By age 3, children can understand that two people can believe different things (Rakoczy, Warneken, & Tomasello, 2007). Four-year-old children understand that people who are presented with different versions of the same event develop different beliefs (Eisbach, 2004; Pillow & Henrichon, 1996), and by age 4 or 5, children become aware that they and other people can hold false beliefs (Moses et al., 2000).

Advanced cognition is needed for children to learn abstract concepts such as belief (Carlson, Moses, & Claxton, 2004; Moses, Carlson, & Sabbagh, 2005). Performance on false-belief tasks, such as the Band-Aid task, is associated with measures of executive function—the abilities that enable complex cognitive functions such as planning, decision making, and goal setting (Hughes & Devine, 2015; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). Advances in executive functioning facilitate children's abilities to reflect on and learn from experience and promote development of theory of mind (Benson, Sabbagh, Carlson, & Zelazo, 2013). For example, one longitudinal study following children from ages 2 to 4 found that advances in executive functioning predicted children's performance on false-belief tasks (Hughes & Ensor, 2007).

Children's performance on false-belief tasks is closely related with language development and competence in sustaining conversations (Bernard & Deleau, 2007; Milligan,
CULTURAL INFLUENCES ON DEVELOPMENT

Culture and Theory of Mind

As children develop theory of mind, they become able to read other people’s minds; that is, they understand other people’s perspectives and can communicate effectively with them. Cultural differences in social norms might influence children’s emerging understanding of the mind. Collectivist cultures emphasize the community, whereas individualist cultures focus on the needs of the individual. These differing perspectives may influence how children come to understand mental states as well as their ability to perspective-take (Taumoepeau, 2015). For example, children from Japan tend to show delayed development on false belief tasks as compared with Western children. (Wellman, Cross, & Watson, 2001). When researchers probed children’s understanding of the false belief task by asking them to explain why the actor searched in the wrong location for his chocolate, Japanese children failed to use “thoughts” as an explanation (Naito & Koyama, 2006). Instead of giving explanations associated with mental states, such as, “He didn’t know it was moved,” Japanese children provided justifications that referenced the physical situation (e.g., “The chocolate is now in a different place”) or interpersonal factors (e.g., “He promised to do so”). The findings suggest a cultural difference in mind reading, whereby Japanese children who are raised with collectivist values focus less on an actor’s mental state and more on his physical and social situation when answering questions about his behavior.

Other research with Samoan children has supported the influence of culture on theory of mind. For example, research with 3- to 14-year-old Samoan children showed delayed development in theory of mind relative to German children (Mayer & Träuble, 2015, 2013). The Samoan children did not reliably succeed until age 8, and one-third of the 10- to 13-year-old children failed the false belief task. Moreover, the transition from failing the task to passing it took longer for Samoan children as compared with German children.

Samoan children’s slow progression on theory of mind tasks is consistent with the Pacific Island doctrine of opacity of mind (Slaughter & Perez-Zapata, 2014). Mindreading or perspective taking is not encouraged. Samoan culture de-emphasizes internal mental states as explanations for behavior. Samoan children, therefore, are not exposed to discussions about the mind. They get little experience considering other people’s thoughts. Research with English-speaking Western samples has shown that conversations about people’s thoughts predicts children’s understanding of false beliefs (Slaughter, Peterson, & Mackintosh, 2007). Therefore, Samoan children’s delayed success on false-belief tasks is likely a result of their culture’s views. In support of this idea is a study of Pacific families living in New Zealand, in which mothers with a stronger Pacific cultural identity referred to beliefs less often when talking to their children than mothers whose Pacific identities were weaker (Slaughter & Perez-Zapata, 2014; Taumoepeau, 2015). Samoan children may be relatively slow to attribute false beliefs because they take longer to recognize that such beliefs exist, when compared to cultures in which minds are less opaque. The culture in which we are immersed influences how we think and how we view the people around us—and even the degree to which we read minds.

What Do You Think?

Is the development of theory of mind universally important? That is, is theory of mind important in all cultures? How might context determine the relevance of theory of mind?

As Astington, & Dack, 2007). Everyday conversations aid children in developing a theory of mind because such conversations tend to center on and provide examples of mental states and their relation to behavior (Ruffman, Slade, & Crowe, 2002). When parents and other adults speak with children about mental states and emotions, connect them to behaviors and experiences, and discuss causes and consequences, children develop a more sophisticated understanding of other people’s perspectives (Pavarini, Hollanda Souza, & Hawk, 2012; Slaughter, Peterson, & Mackintosh, 2007). In addition, siblings provide young children with opportunities for social interaction, pretend play, and practice with deception; children with siblings perform better on false-belief tests than do
only children (Jenkins & Astington, 1996; McAlister & Peterson, 2007; McAlister & Peterson, 2013). Success in false-belief attribution tasks is most frequent in children who are the most active in shared pretend play (Schwebel, Rosen, & Singer, 1999). Elementary school students' success on false-belief tasks predicts their competence at understanding other people's perspectives in everyday conversations and interactions (De Rosnay et al., 2014). Theory of mind is influenced by interactions with others but also influences interactions with others. Throughout childhood, from ages 2 through 12, theory of mind predicts measures of prosocial behavior, such as helping others (Imuta, Henry, Slaughter, Selcuk, & Ruffman, 2016).

The contexts in which children are embedded contribute to their developing understanding of the mind. Children in many countries, including Canada, India, Thailand, Norway, China, and the United States, show similarity in the onset and development of theory of mind between the ages of 3 and 5 (Callaghan et al., 2005; Melinder et al., 2006; Wellman, Fang, & Peterson, 2011; Sabbagh et al., 2006). Children reared in some contexts, however, show a very different pattern in understanding theory of mind (Lillard, 1998; Vinden, 1996). A study of 8-year-old children from Peru used a culturally appropriate version of the Band-Aid box task in which a sugar bowl contained tiny potatoes (Vinden, 1996). At first the children believed the bowl contained sugar. After learning that it contained potatoes, they answered typical false-belief questions incorrectly, predicting that others would respond that the bowl contained potatoes. Even at age 8, well after Western children succeed on similar tasks, the Peruvian children responded incorrectly, unable to explain why others might initially believe that the bowl contained sugar and be surprised to learn otherwise. One explanation is that the children in this study were raised in an isolated farming village where farmers worked from dawn to dusk, and there was no reason nor time for deception (Vinden, 1996). The Peruvian children's culture did not include ideas such as false belief, or deceiving others, as their day-to-day world was concerned more with tangible activities and things rather than considerations of people's thoughts. The culture in which we are immersed influences how we understand the nature of people's thoughts.

**Metacognition**

Theory of mind is a precursor to the development of metacognition (Lecce, Demicheli, Zocchi, & Palladino, 2015). Between the ages of 2 and 5, children's understanding of the mind grows; they become aware that the mind is where thinking takes place. Between 3 and 5, children come to understand that they can know something that others do not (essential for success on false-belief tasks), that their thoughts cannot be observed, and that there are individual differences in mental states (Flavell, Flavell, & Green, 1983; Pillow, 2008). They begin to understand that someone can think of one thing while doing something else, that a person whose eyes and ears are covered can think, and that thinking is different from talking, touching, and knowing (Flavell et al., 1995). However, young children's understanding of the mind is not complete. Three- and 4-year-old children do not understand that we think even when we are inactive. They look for visible indicators of thinking—perhaps one reason why teachers of young children refer to "putting on your thinking cap"—and assume their absence indicates the absence of thought. It is not until middle childhood that children understand that the mind is always active (Flavell, 1999; Flavell et al., 1983, 1995). Likewise, preschoolers tend to think of the mind as simply a container for items, but older children tend to see the mind as an active constructor of knowledge that receives, processes, and transforms information (Chandler & Carpendale, 1998; Flavell, 1999).

Young children show limited knowledge of memory functions. Four-year-olds recognize that increasing the number of items on a list makes recall more difficult and that longer retention intervals increase the likelihood of forgetting (Lyon & Flavell, 1993; Pillow, 2008; Wellman, 1977). But they know little about the effectiveness of deliberate
memory strategies. In one study, when 4-year-olds were asked to compare the effectiveness of strategies for free recall, they judged looking at the items to be recalled as more effective than naming, rehearsing, or categorizing them (Justice, 1986). Children in kindergarten showed no preference among the four strategies, but second graders judged rehearsal and categorization as more effective than naming or looking. However, one recent study suggests that preschoolers’ poor memory performance may result more from over-optimism than from metacognitive deficits (Lipowski, Merriman, & Dunlosky, 2013). As we will discuss in Chapter 11, young children have a strong sense of self-confidence and tend to believe that they will be successful in all endeavors. This overconfidence may overshadow their understanding of how their minds work, leading to biased estimates of their abilities (Lipowski et al., 2013).

Whereas young children tend to see the mind as static container for information, older children view it as an active manipulator of information (Flavell, 2004). Advances in metacognition accompany prefrontal development and enable school-age children to become mindful of their thinking and better able to consider the requirements of a task, determine how to tackle it, and monitor, evaluate, and adjust their activity to complete the task (Ardila, 2013; Kuhn, 2000).

**Metamemory**, an aspect of metacognition, refers to the understanding of one’s memory and the ability to use strategies to enhance it; metamemory improves steadily throughout the elementary school years (Cavanaugh & Perlmutter, 1982; Flavell, 2004; Lecce et al., 2015). Older preschool children have an understanding that one needs to do “something” to prepare for a memory assessment, but they often do not know what to do (Ornstein, Light, Ornstein, & Light, 2010). Kindergarten and first-grade children understand that forgetting occurs with time and studying improves memory, but by age 8 or 9, metamemory permits children to accurately evaluate what they know, such as vocabulary words, and learn more effectively. Older children perform better on cognitive tasks because metacognition permits them to plan. They can evaluate the task; determine how they will approach it given their cognitive resources, attention span, motivation, and knowledge; and deploy metamemory to choose and monitor the use of memory strategies that will permit them to successfully store and retrieve needed information (Camos & Barrouillet, 2011; Kuhn, 2000; Schneider & Pressley, 2013). These abilities improve with experience, neural maturation, and advances in executive functioning (Roebers & Feurer, 2016).

### Thinking in Context 7.3

1. Identify some personal examples of attention, working memory, and long-term memory from your own childhood. What is your earliest memory of this nature? How have your information processing capacities changed as you have grown older?
2. Physical and motor development have clear implications for cognitive development during infancy. Is the same true in childhood? In what ways might physical and motor development influence cognition in school-age children?
3. Recall from Chapter 1 that development is influenced by multiple contexts. How might contextual influences—family, neighborhood, sociocultural context, and even cohort or generation—influence aspects of cognitive development, such as theory of mind?

### Information Processing in Adolescence

**LO 7.4 Explain how advances in brain development during adolescence influence memory, metacognition, and scientific reasoning.**

Adolescents’ advances in the ability to think abstractly and demonstrate hypothetical-deductive reasoning are also the result of improvements in information processing capacities that take place from childhood through adolescence. These improvements affect many
aspects of information processing, such as attention, memory, knowledge base, and speed (Kail, 2008; Luna, Garver, Urban, Lazar, & Sweeney, 2004).

ATTENTION, MEMORY, AND EXECUTIVE FUNCTION IN ADOLESCENTS

Greater control over attention enables adolescents to deploy it selectively, focusing on stimuli deemed important while tuning out others and remaining focused even as task demands change. With increases in attention, adolescents are better able to hold material in working memory while taking in and processing new material (Barrouillet, Gavens, Vergauwe, Gaillard, & Camos, 2009). For example, at age 13, Julia is able to tune out the background noise in class to listen to her teacher, determine what is important, take notes, and remember what she's writing while listening to her teacher. She can shift her attention to take notes from movies shown in class and remain focused when the class format changes to discussion.

As we gain increasing control over our cognitive system we also become better at response inhibition, that is, not responding or not activating cognitive operations in response to a stimulus. Advances in response inhibition enable adolescents to adapt their responses to the situation by inhibiting well-learned responses when they are inappropriate to the situation and thereby speeding cognitive processing (Luna, Paulsen, Padmanabhan, & Geier, 2013; Luna et al., 2004). For example, Hiro is now able to keep himself from raising his hand in response to the teacher's question, telling himself, “I need to give other students a chance, too.” The ability to control and inhibit responses emerges first in infancy and advances through childhood, with substantial gains in adolescence (Geier, Terwilliger, Teslovich, Velanova, & Luna, 2010; Zhai et al., 2014). However, the neurological changes that underlie response inhibition continue to develop into the 20s and influence many aspects of adolescent development, including their propensity for risk-taking behavior, as discussed later in this chapter (Albert, Chein, & Steinberg, 2013; Luna et al., 2013).

Working memory reaches adult-like levels by about age 19 and continues to improve into the 20s alongside neurological maturation (Isbell, Fukuda, Neville, & Vogel, 2015; Murty, Calabro, & Luna, 2016; Simmonds & Luna, 2015). Combined with a growing knowledge base and increased strategy use, advances in working memory result in more sophisticated, efficient, and quick thinking and learning. Now adolescents can retain more information at once, better integrate prior experiences and knowledge with new information, and combine information in more complex ways (Cowan et al., 2010; Gaillard, Barrouillet, Jarrold, & Camos, 2011). These advances support adolescents’ abilities to solve geometry problems, employ the scientific method, and solve other complex problems. Increased capacities for working memory mean that adolescents can hold more ideas in mind and manipulate them to reason about problems and about ideas and the nature of thinking itself (i.e., metacognition; Cowan et al., 2010; Gaillard et al., 2011; Murty et al., 2016).

THINKING AND METACOGNITION IN ADOLESCENCE

As metacognition develops through middle adolescence, teenagers are better able to plan how they take in, manipulate, and store information (Ardila, 2013; van der Stel & Veenman, 2013). They are better able to understand how they learn and remember and to choose and deploy strategies that enhance the representation, storage, and retrieval of information. As an 11th grader, Travis, explains, “Studying for a biology exam is really different than studying for a history exam. In biology, I visualize the material, but when I study for history, I make up stories to help me remember it all.” Travis illustrates the metacognitive skills that emerge in adolescence because he is able to evaluate his understanding and adjust his strategies to the content. Adolescents’ abilities to apply metacognition in real-world settings continue to develop into late adolescence and early adulthood.
Developmental scientists’ work is often called upon to inform legal issues and influence social policy, as illustrated by a series of Supreme Court cases (Bonnie & Scott, 2013; Cohen & Casey, 2014).

Can adolescents who have been convicted of serious crimes face the death penalty? In *Roper v. Simmons*, the Supreme Court considered whether the death penalty is constitutional as applied to minors. Should minors be subject to the same punishments as adults? At the time, 21 states in the United States permitted the death penalty for adolescents under the age of 18, and most of them permitted it at the age of 16 (Steinberg & Scott, 2003). As the case moved to the Supreme Court, developmental scientists collaborated with the American Psychological Association to submit an amicus curiae (“friend of the court”) brief to inform the justices about the developmental research relevant to the case, specifically research on adolescent judgment and decision making. The brief explained that adolescents’ developmental immaturity makes them less culpable for crimes and justifies a more lenient punishment than that given to adults, but adolescents are actors who retain responsibility for the crime (Caulfman & Steinberg, 2012; Steinberg & Scott, 2003).

Recall that the lag between the development of the emotional part of the brain and the prefrontal cortex, responsible for executive functioning and decision making, contributes to adolescents’ tendency to feel strong emotions and impulses that they may have difficulty controlling (Casey & Caudle, 2013). Research suggests that adolescents, especially males, react impulsively to threat cues more so than do adults or children, even when the adolescent is instructed not to respond. This response is associated with enhanced activity in the limbic regions of the brain responsible for detecting and assigning value to emotion (Dreyfuss et al., 2014).

In addition to neurological development, psychosocial development, specifically susceptibility to peer influence and future orientation, plays a prominent role in adolescent decision making and behavior (Albert et al., 2013). When adolescents make decisions in response to hypothetical dilemmas in which they must choose between engaging in an antisocial behavior suggested by friends and a prosocial one, their choices suggest that susceptibility to peer influence increases between childhood and early adolescence, peaking around age 14 and declining slowly during high school (Allen & Antonishak, 2008; Steinberg & Monahan, 2007). Not only are adolescents’ decisions more likely to be influenced by peers, but simply thinking about peer evaluation increases risky behavior. Moreover, the presence of peers can increase risky behavior even when the probability of a negative outcome is high (Centifanti, Modecki, MacLellan, & Gowling, 2014; Smith et al., 2014).

Similarly, adults demonstrate a greater ability to envision themselves in the future than do adolescents (Nurmi, 1991; Steinberg et al., 2009). A poor sense of future orientation is associated with participation in risky activities (Chen & Vazsonyi, 2011, 2013). Difficulty envisioning the future combined with the influence of strong emotions, susceptibility to peers, and poor self-control can compromise adolescents’ decisions despite their neurological and cognitive advances. In all of these ways, psychosocial factors influence how adolescents weigh the costs and benefits in making decisions: To the extent that teens are less psychosocially mature than adults, their decisions are likely to be inferior to those of adults, even if they score similarly to adults on cognitive measures (Cauffman & Steinberg, 2000, 2012; Modecki, 2014).

In the case of *Roper v. Simmons*, in 2005 the Supreme Court ruled against capital punishment for minors on the basis of their lack of maturity and susceptibility to peer influence (Greenhouse, 2005; Steinberg, 2013). In 2010 and 2012, under a similar rationale, in *Florida v. Graham*, *Miller v. Alabama*, and *Jackson v. Hobbs*, the Supreme Court ruled that minors cannot be sentenced to life in prison without parole (American Psychological Association, 2012).

**What Do You Think?**

1. **To what degree do you think adolescents should be culpable for criminal offenses they commit? Do you agree with the Supreme Court decisions against the death penalty or life in prison without parole for adolescents? Why or why not?**

2. **Do you advocate using developmental science research to make policy decisions such as this? Why or why not?**
Metacognition improves during adolescence and plays an important role in the development of scientific reasoning because it is by experimenting with and reflecting on cognitive strategies that adolescents learn about and come to appreciate logic, which they increasingly apply to situations (Kuhn, 2000; van der Stel & Veenman, 2013; Weil et al., 2013). Improvements in information processing capacities and metacognition enable adolescents to engage in the more sophisticated, reasoned, and efficient problem solving that underlies capacities for manipulating abstract mental representations and engaging in the hypothetical-deductive thinking that is characteristic of scientific reasoning (Bullock, Sodian, & Koerber, 2009; Demetriou, Christou, Spanoudis, & Platsidou, 2002; Kuhn, 2012). Although adolescents show advances in scientific reasoning, their reasoning tends to emphasize single solutions to problems.

In one study, 6th-grade students were presented with detailed pictorial and written information about variables that were explained to have either a causal or noncausal influence on a hypothetical problem, such as the likelihood of an avalanche occurring. The task was to apply the information in predicting outcomes. Although given information about five different variables, the students consistently chose only one factor as influential, although they chose different variables across trials. For example, a pair of students chose snow pollution as a cause of an avalanche, referring to the written materials, “Because it shows the snow pollution is high; snow is what causes an avalanche.” Yet for a second prediction, the student pair turned to another single variable, slope angle, explaining that “slope angle is an important part of how snow falls.” In a third prediction, they turned to still another, different, single factor, wind speed: “We chose the wind speed because it affects how fast the snow falls” (Kuhn, Pease, & Wirkala, 2009, p. 439). Although adolescents can demonstrate scientific thinking, they tend to consistently prefer single-factor solutions as they are not yet able to coordinate the effects of multiple causal influences on outcomes (Kuhn, Iordanou, Pease, & Wirkala, 2008; Kuhn et al., 2009). For many young people, the more complex reasoning required to consider multiple influences at once, as well as a more sophisticated understanding of the nature of knowledge and scientific phenomena, emerges in early adulthood.

**Brain Development and Adolescent Cognition**

Changes in the brain, especially the prefrontal cortex, underlie many improvements in information processing capacities. As the structure of the prefrontal cortex changes, with decreases in gray matter and increases in white matter, cognition becomes markedly more efficient (Asato, Terwilliger, Woo, & Luna, 2010). Myelination underlies improvements in processing speed during childhood and adolescence, permitting quicker physical and cognitive responses (Silveri, Tzilos, & Yurgelun-Todd, 2008). Compared to children, not only do adolescents show faster reaction speed in gym class, but they are quicker at connecting ideas, making arguments, and drawing conclusions. Processing speed increases and reaches adult levels at about age 15 and is associated with advances in working memory and cognition (Coyle, Pillow, Snyder, & Kochunov, 2011).

Development of the prefrontal cortex as well as the cerebellum leads to enhanced executive function, capacities that allow us to control and coordinate our thoughts and behavior, including attention, planning, evaluating, judging, goal-directed behavior, and response inhibition (Ardila, 2013; Tiemeier et al., 2010). Connections between the prefrontal cortex and various brain regions strengthen, improving working memory and permitting rapid communication and enhanced cognitive and behavioral functioning (Tamnes et al., 2013; van den Bosch et al., 2014). With these advances in brain development, routine decisions become automatic, requiring fewer cognitive resources and therefore enabling adolescents to redirect their thinking toward more complicated problems.
Decision Making

Adolescents are faced with a variety of decisions each day, ranging from the mundane, such as when to clean their rooms and how to spend an afternoon, to decisions that are important to their health, well-being, and future, such as which friendships to foster, whether to drink or smoke, what classes to take in school, and whether and where to go to college. With age and experience, adolescents take on increasing decision-making responsibility. Cognitive advances permit adolescents to engage in more sophisticated thinking than ever before and to participate meaningfully in decision making.

Researchers who study decision making from a cognitive perspective explain decision making as a rational process in which, when faced with a decision, people follow several steps. They first identify decision options, then identify the potential positive and negative consequences for each option (i.e., the pros and cons). They estimate how likely each potential outcome is, rate how desirable each outcome is, and finally combine all of this information to make a decision (Furby & Beyth-Marom, 1992). Research from this perspective has shown that adolescents often are capable of demonstrating rational decision making that is in line with their goals and is comparable to that of adults (Reyna & Farley, 2006; Reyna & Rivers, 2008). For example, comparisons of adolescents and adults' decisions on hypothetical dilemmas—such as whether to engage in substance use, have surgery, have sex, or drink and drive—show that adults spontaneously generate more consequences to each decision option and are more likely to spontaneously mention risks and benefits of each option (Furby & Beyth-Maram, 1992; Halpern-Felsher & Cauffman, 2001). However, both adolescents and adults show an optimistic bias wherein they view their own risks as lower than those of peers (Halpern-Felsher & Cauffman, 2001). Moreover, adolescents and adults generally do not differ in their ratings of the perceived harmfulness of risks; in fact, in many cases adolescents perceive greater risks than do adults (Reyna & Farley, 2006).

If adolescents are aware of the risks entailed in decisions, perhaps more so than adults, why do they often make poor decisions and engage in risk taking? Although adolescents’ abstract reasoning abilities permit them to consider possibilities, they often do not consider practicalities associated with each option. Adolescents are more approach oriented in response to positive feedback and less responsive to negative feedback than are adults (Cauffman et al., 2010; Javadi, Schmidt, & Smolka, 2014). Adolescents tend to place more importance on the potential benefits of decisions (e.g., social status, pleasure) than their estimation of the potential costs or risks (e.g., physical harm, short- and long-term health; Rivers, Reyna, & Mills, 2008; Shulman & Cauffman, 2013).

Neurological research supports these findings. For example, in the presence of rewards, adolescents show heightened activity in the brain systems that support reward processing and reduced activity in the areas responsible for inhibitory control, as compared with adults (Paulsen, Hallquist, Geier, & Luna, 2014; Smith, Steinberg, Strang, & Chein, 2015). Similarly, adolescents who engage in high-risk behavior more often show less activation of the parts of the prefrontal cortex that are associated with decision making (Luna et al., 2013; Shad et al., 2011).

Recall from Chapter 4 that maturation of the prefrontal cortex, which is associated with executive functions including decision making, lags behind the development of the limbic system, which is responsible for emotional arousal (Mills, Goddings, Clasen, Giedd, & Blakemore, 2014). This difference in maturational timing means that, until maturation of the prefrontal cortex catches up to the limbic system, adolescents feel emotionally charged before they have corresponding self-regulation and decision-making abilities (Albert et al., 2013; Van Leijenhorst et al., 2010). Adolescents show greater activity of the reward parts of the brain than adults and are assumed to be susceptible to risk taking in situations of heightened emotional arousal (Figner, Mackinlay, Wilkening, & Weber, 2009; Mills et al., 2014). Their decisions about risk taking are swayed by so-called...
hot processes, the emotional arousal-driven thinking that tends to interfere with “cold” rational processes of cost–benefit weighing (van Duijvenvoorde, Jansen, Visser, & Huizenga, 2010; Zelazo & Carlson, 2012). In other words, adolescents often act impulsively, seemingly without thought, and their decisions often are influenced by affective motivators such as the desire for pleasure, relaxation, or excitement (Mills et al., 2014; van Duijvenvoorde et al., 2015).

Adolescents are capable of demonstrating rational decision making that is in line with their goals and is comparable to that of adults, but these results are seen under ideal laboratory conditions (Reyna & Rivers, 2008). In practice, decision making is more complex and influenced by situational, emotional, and individual difference characteristics, such as the presence of peers, temptation of high rewards, excitement, impulsivity, and sensation seeking (Smith, Chein, & Steinberg, 2013). Laboratory studies of decision making usually present adolescents with hypothetical dilemmas which are very different from the everyday decisions they face. Everyday decisions have personal relevance, require quick thinking, are emotional, and often are made in the presence and influence of others. Adolescents often feel strong emotions and impulses that they may be unable to regulate, due to the still-immature condition of their prefrontal cortex (Casey & Caudle, 2013). Therefore laboratory studies of decision making are less useful in understanding how young people compare with adults when they must make choices that are important or occur in stressful situations in which they must rely on experience, knowledge, and intuition (Steinberg, 2013). When faced with unfamiliar emotionally charged situations, spur-of-the-moment decisions, pressures to conform to peers, poor self-control, and risk and benefit estimates that favor good short-term and bad long-term outcomes, adolescents tend to reason more poorly than adults (Albert et al., 2013; Defoe, Dubas, Figner, & Aken, 2012). Figure 7.4 illustrates the many influences on adolescent decision making.

When is adolescents’ thinking adult-like enough that they can be treated as adults? The answer to this question holds implications for a variety of contexts. For example, when is an adolescent able to make medical decisions, such as for elective surgery? In academic contexts, when is an adolescent able to drop out of school without parental permission? Perhaps the most controversial question pertains to legal contexts: When should an adolescent offender be tried or sentenced as an adult? At what age can an offender be given the death penalty or sentenced to life in prison without parole? This policy issue is discussed in the Lives in Context feature.

Although many adults display faulty decision making, it is adolescents who are in need of protection from their poor decisions because the consequences of their bad decisions—such as accepting a ride from a friend who has been drinking—are potentially more serious and long-lasting. Adult guidance aids adolescents in learning how to make good decisions. Such guidance can include helping adolescents consider options, the pros and cons of each, the likelihood of each, and how to weigh information to come to a decision. Experience making decisions, learning from successes and failures, coupled with developments in cognition, self-control, and emotional regulation, leads to adolescent decision making that is more reflective, confident, and successful.
Thinking in Context 7.4

1. Some might argue that advances in metacognition are the most important aspect of cognitive development during adolescence. Why might metacognition be particularly important? Do you think that it is the most important advance? Why or why not?

2. Considering the biological developments of adolescence described in Chapter 3, describe some ways in which adolescent decision making is a product of interactions among puberty, brain development, cognitive growth, and contextual influences such as parents, peers, and community.

Information Processing in Adulthood

LO 7.5 Compare patterns of change in working memory, long-term memory, problem-solving capacities, and wisdom in adulthood.

Changes in thinking and problem solving during adulthood are influenced by adults’ capacities for information processing. Changes in attention, working memory, and processing speed influence how adults interact with their world, the development of expertise, and problem-solving skills. Older adults are often described as wise. What is wisdom? How do information processing abilities change during the adult years?

Attention, Memory, and Processing Speed in Adults

“Where are my keys?” Martinique asked for what felt like the 100th time this week. “They were in the refrigerator last time you lost them. Have you checked under your sandwich?” asked her 15-year-old son, Ramon. “Ok wise guy, I’ll look in the fridge.” “Um Mom? You’re holding your keys. They’re in your hand.” “Yikes! I’d forget my head if it weren’t connected to my neck!” Martinique exclaimed. Are middle-aged adults like Martinique doomed to declining cognitive abilities? How do information processing capacities change over adulthood?

Attention

In what ways does attention change with age? Researchers who study attention examine how much information a person can attend to at once, the ability to divide attention and change focus from one task to another in response to situational demands, and the ability to selectively attend and ignore distracters and irrelevant stimuli. From middle adulthood into older adulthood it becomes more difficult to divide attention, that is, to engage in two complex tasks at once and focus on relevant information (Radvansky, Zacks, & Hasher, 2005). As with other capacities, age-related declines in attention are not uniform across adults, and these differences predict variations in cognitive performance. In one study, those who performed better on cognitive tasks were more attracted to and spent more time viewing novel stimuli than those who performed at average levels (Daffner, Chong, & Riis, 2007). Moreover, the magnitude of the difference between adults with exceptional versus average performance grew from middle adulthood into old age; engagement and a preference for novelty become better predictors of cognitive performance increases with age.

Sensory capacities, such as vision and hearing, decline with age (see Chapter 4) and are associated with age-related declines in cognition (Baldwin & Ash, 2010). Sensory impairments prevent some information from getting into the cognitive system in the first place, so that older adults may never be aware that they have missed it. Reductions in sensory capacities are associated with impaired attention and slower cognition (Anstey, Hofer, & Luszcz, 2003; Wingfield, Tun, & McCoy, 2005). In one study of adults of
different ages, 11% of the individual differences in young adults’ scores on cognitive measures were associated with sensory impairment, whereas sensory impairment among older adults accounted for 31% of the individual differences in cognitive scores (Lindenberger & Baltes, 1997). Sensory impairments may prevent individuals from attending to stimuli; however, research suggests that neurological changes are the cause of deficits in both attention and sensory capacities (Lindenberger, Scherer, & Baltes, 2001).

Response inhibition becomes more challenging with age, and adults find it increasingly difficult to resist interference from irrelevant information to stay focused on the task at hand (Sylvain-Roy, Lungu, & Belleville, 2014). Researchers have assessed attention with laboratory tasks in which participants are presented with a series of letter combinations and told to press the space bar only when they see a particular combination (such as T-L); they are to ignore all other combinations. In such tasks, adults’ performance declines steadily from the 30s on. Older adults make more errors of commission—pressing the space bar after incorrect letter combinations—suggesting that they are less able to inhibit responding to extraneous information (Mani, Bedwell, & Miller, 2005). Older adults also make more errors of omission—not pressing the space bar in response to the correct sequence—when the task was accompanied by extraneous noise. In everyday life, these changes in attention might make older adults appear more easily distracted, less able to attend, and less able to take in information.

In everyday life, however, changes in attention are not always evident (Kramer & Madden, 2008). Experience and practice can make a big difference in adults’ information processing capacities (Glisky, 2007). People in occupations that require detecting critical stimuli and engaging in multiple complex tasks, such as air traffic controllers, develop expertise in focusing and maintaining attention and show smaller declines with age (Kennedy, Taylor, Reade, & Yesavage, 2010; Morrow et al., 2003). Practice also improves performance and reduces age-related decline. For example, training in how to divide attention between two tasks by using selective attention—switching back and forth between mental operations—improves the performance of older adults as much as that of younger adults, although age differences in performance remain (Kramer & Madden, 2008).

Older adults are less likely to inhibit irrelevant items, are slower at inhibiting a response, and are more likely to retrieve irrelevant items, especially in tasks that require a high memory load and include the presence of distracters (Bloemendaal et al., 2016; Gazzaley, Sheridan, Cooney, & D’Esposito, 2007; Rowe et al., 2010).

**Working Memory**

Working memory changes substantially over the adult years. Working memory is essential to cognitive competence as it underlies performance on a range of tasks, including problem solving, decision making, language comprehension, abstract reasoning, and complex learning (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010). Age-related declines in working memory span from the 20s through the 60s and are supported by cross-sectional and longitudinal research (Emery, Hale, & Myerson, 2008).

Changes in attention influence declines in working memory (Rowe, Hasher, & Turcotte, 2010; Sylvain-Roy et al., 2014). With age, older adults become more susceptible to distraction and are less likely to discard distracting information from working memory, which then leaves less space in working memory for completing a given task (Radvansky, Zacks, & Hasher, 2005; Van Gerven, Van Boxtel, Meijer, Willems, & Jolles, 2007). However, once material is encoded in working memory, healthy adults of all ages retain the ability to exert control over working memory—they are able to orient their attention within working memory (and stay on task; Mok, Myers, Wallis, & Nobre, 2016). Problems with working memory vary with the number of tasks and task demands: The greater the number of tasks and demands, the worse the performance (Kessels, Meulenbroek, Fernandez, & Olde Rikkert, 2010; Voelcker-Rehage, Stronge, & Alberts, 2006).
Consider an experiment that requires adults to attend and respond to two tasks at once, such as tapping a computer screen on two alternating targets whose sizes vary systematically at the same time as generating a list of random numbers, spoken at 2-second intervals. With age, most adults find it is more difficult to simultaneously perform a motor and cognitive task such as this than it is to perform either task alone. However, practice in the motor task makes it more automatic, reducing the demands on working memory. In this way, practice can reduce (but not eliminate) age-related deficits in cognitive performance (Voelcker-Rehage & Alberts, 2007).

Age-related decline is less apparent in cognitive tasks that are more passive and less attentionally demanding, such as digit recall and visual pattern recall tasks (Bisiacchi et al., 2008). When working memory maintenance systems are taxed, as in the case of interference, older adults do not perform as well as young and middle-aged adults. **Proactive interference** occurs when information that has previously been remembered interferes with memory for new information (Bowles & Salthouse, 2003). Students may experience proactive interference if they have studied a foreign language for a couple of years and then switch to beginner-level classes in another foreign language. The language they have already learned can interfere with ability to learn and use the new language. Older adults are more susceptible to interference effects than are younger adults, even when they have learned the material equally well (Jacoby, Wahlheim, Rhodes, Daniels, & Rogers, 2010). Researchers study this with working memory span tasks, in which participants are presented with repeated trials of material that they are asked to remember, recall, and then forget. Frequently the old, supposedly forgotten material interferes with older adults’ ability to store new material.

With age, adults are less likely to apply the memory strategies of organization and elaboration (Braver & West, 2008; Craik & Rose, 2012). In both of these strategies, the person must link new information with existing knowledge. From middle adulthood into old age, adults begin to have more difficulty retrieving information from long-term memory, which makes them less likely to spontaneously use organization and elaboration as memory strategies (Glisky, 2007).

**Context, Task Demands, and Memory Performance.** Many laboratory tests of working memory entail tasks that are similar to those encountered in school settings. Middle-aged and older adults may be less motivated by such tasks than younger adults, who likely have more recent experience in school contexts. Laboratory findings, therefore, may not accurately illustrate the everyday memory capacity of middle-aged and older adults (Salthouse, 2012). For example, when the pace of a memory task is slowed, or participants are reminded to use organization or elaboration strategies, middle-aged and older adults show better performance (Braver & West, 2008). In addition, the type of task influences performance. In one study, adults aged 19 to 68 completed memory tests under two conditions: a pressured classroom-like condition and a self-paced condition. When participants were shown a video and tested immediately (classroom-like condition), younger adults showed better recall than did the middle-aged adults. However, when participants were given a packet of information and a video to study on their own (self-paced condition), midlife adults performed just as well as young adults on recall three days later (Ackerman & Beier, 2006; Beier & Ackerman, 2005). This suggests that the ways in which we learn and remember change with age and experience.

The declines in memory evident in laboratory research are less apparent in everyday settings (Salthouse, 2012). Knowledge of facts (e.g., scientific facts), procedures (e.g., how to drive a car), and information related to one’s vocation either remain the same or increase over the adult years (Schaie, 2013), and adults’ experience and knowledge of their cognitive system (metacognition) enable them to use their memory more effectively. For example, they use external supports and strategies to maximize their memory, such as by organizing their notes or placing their car keys in a designated spot where they can reliably be found (Schwartz & Frazier, 2005). As with attention, memory declines vary with the individual and task. Most adults compensate for declines and show little to no differences in everyday
settings; however, chronic stress impairs working memory (Lee & Goto, 2015). Midlife adults who feel overwhelmed in daily life, such as those faced with many conflicting responsibilities and stressors that demand a great deal of multitasking, are more likely to rate their memory competence as poor (Vestergren & Nilsson, 2011). Multitasking is difficult for all adults, but it becomes more challenging in older adulthood. Managing and coordinating multiple tasks by switching attention among two sets of stimuli is associated with greater disruptions in working memory in older adults as compared with younger adults (Clapp et al., 2011). If, however, older adults have the opportunity to slow down to a pace with which they feel comfortable, they can show performance on working memory tasks similar to that of younger adults (Verhaeghen et al., 2003).

**Emotion and Working Memory.** Age differences in working memory are usually assessed by tasks that require older and younger adults to complete various tasks in a laboratory setting. Although standard lab tasks often show age-related declines in working memory, there are instances in which older adults show capacities similar to those of younger adults. Older adults score better on measures of complex thinking when the task evokes positive feelings than when the task is designed to evoke neutral or negative feelings (Carpenter, Peters, Västfjäll, & Isen, 2013). For example, one study examined age differences in working memory for emotional versus visual information. Findings demonstrate that, despite an age-related deficit for visual information, working memory for emotion was unimpaired (Mikels, Larkin, Reuter-Lorenz, & Cartensen, 2005). Positive mood enhances working memory capacity so that adults are better able to hold onto information while processing task-irrelevant information when in a positive mood. However, a negative mood is not related to either an increase or decrease in working memory (Storbeck & Maswood, 2016).

In another study, although young adults were better able to recall neutral words than were older adults, there were no age differences in recall of emotional words such as “peace,” “joy,” “love,” or “smile” (Mammarella, Borella, Carretti, Leonardi, & Fairfield, 2013). A meta-analysis of the positivity effect of 100 studies shows that older adults are naturally biased toward recalling positive over negative information, although younger adults show the reverse, with more attention on the negative (Reed, Chan, & Mikels, 2014).

What are the reasons for this positivity effect in older adults’ memories? It may be due to their greater focus on managing their emotions. That is, older adults may use cognitive control mechanisms that enhance positive and diminish negative information in order to feel good (Mather & Carstensen, 2005). This finding has appeared in research with Chinese and Korean adults, suggesting that the positivity bias with age may appear cross-culturally (Gutchess & Boduroglu, 2015). Although they are often studied separately, emotion and cognition are intertwined (Reed & Carstensen, 2012). Emotion characterizes most real-life decisions, suggesting that older adults are likely able to focus their attention and cognitive capacities on the task at hand, if it has real-world emotional relevance, such as decisions about health care, financial, and living situations (Samanez-Larkin, Robertson, Mikels, Carstensen, & Gotlib, 2009).

**Long-Term Memory**

Age-related changes in working memory also contribute to changes in long-term memory. As cognitive processing slows, most adults show difficulties with recall. For example, while watching a television show, an older adult may retain fewer details than a young adult. However, the various types of long-term memory show different patterns of change. Semantic memory (memory for factual material) shows little age-related decline, but episodic memory (memory for experiences) tends to deteriorate with age (St-Laurent, Abdi, Burianová, & Grady, 2011).

Episodic memory shows increases from adolescence to about 25 or 30, then begins a steady decline (Bialystok, Craik, Bialystok, & Craik, 2010). Autobiographical memory shows predictable patterns of deterioration. When older adults are asked to discuss a
Sleep is essential for information processing, including forming and consolidating memories (Stickgold & Walker, 2013). Sleep also plays a role in forming neural connections and pruning existing connections (Tononi & Cirelli, 2014). Recent research suggests that sleep is even more critical to maintaining neurocognitive functioning. Specifically, sleep may act as a “mental janitor” clearing the brain of biological waste that accumulates as a result of daily thinking (Xie et al., 2013). The spaces between neurons are filled with cerebrospinal fluid whose flow washes away the cells’ daily waste.

In a groundbreaking study, Maiken Nedergaard and colleagues (2013) demonstrated that sleep influences the flow of cerebrospinal fluid in mice. The researchers injected dye into the cerebrospinal fluid of mice and monitored the animals’ brains, tracking the movement of dye. When the mice were awake the dye barely moved, flowing only along the brain’s surface. In contrast, when the mice were asleep the dye indicated that the cerebrospinal fluid flowed rapidly and reached further into the brain.

Why does the fluid flow more easily during sleep? The team discovered that the increased flow was possible because when mice went to sleep, their brain cells shrank. The space between brain cells increased during sleep, making it easier for fluid to circulate. When an animal woke up, the brain cells enlarged again and the fluid’s movement between cells slowed to a trickle. The sleeping mice processed neural wastes, such as excess beta-amyloid, twice as quickly as the awake mice, suggesting that sleep plays a critical role in the brain’s waste management. This brain-cleaning process has been observed in rats and baboons, but it has yet to be studied in humans. Yet these findings might explain why we may not think clearly after a sleepless night. More important, the waste management role of cerebrospinal fluid might offer a new way of understanding and perhaps treating brain diseases that involve the buildup of wastes, such as amyloid plaques in Alzheimer’s disease.

**What Do You Think?**

*How does sleep affect your thinking and performance? What do these results mean to you?*
life, memory is malleable and we often revise our memories in light of new experiences. However, it also appears that older adults recall fewer details from recent events (within the past 5 years) and different types of details, than do younger adults. This suggests that older and younger adults differ in what stimuli they attend to and select for processing (Gaesser, Sacchetti, Addis, & Schacter, 2010; Piolino et al., 2006; Piolino et al., 2010).

Contextual factors play a role in the rate of cognitive change. Similar to findings of cohort differences in intelligence scores, there are generational differences in overall cognitive performance that are maintained throughout life. Specifically, younger cohorts show better performance on a range of cognitive measures and less steep age-related declines (Gerstorf, Ram, Hoppmann, Willis, & Schaie, 2011; see Figure 7.6). Possible factors underlying cohort differences include secular trends in educational systems, disease prevalence, years of education, and quality of education.

**Processing Speed**

The greatest change in information processing capacity with age is a reduction in the speed of processing. Simple reaction time tasks, such as pushing a button in response to a light,
reveal a steady slowing of responses from the 20s into the 90s (see Figure 7.5; Rozas et al., 2008; Salthouse, 1993). The more complex the task, the greater the age-related decline in reaction time. However, when reaction time tasks require a vocal response rather than a motor response, age-related declines are less dramatic (Johnson & Rybash, 1993).

In addition, adults’ performance on standard tasks measuring processing speed is influenced by their capacities for attention. Adults who are highly distractible show slowed responding on standard tasks measuring processing speed, but their performance improves when tasks are designed to reduce distractions (e.g., by listing fewer items on a page). Reducing distractions improves performance, and the magnitude of improvement as a result of reducing distractions on tests of processing speed increases with age (Lustig, Hasher, & Tonev, 2006).

Declines in processing speed with age predict age-related declines in memory, reasoning, and problem-solving tasks (Levitt et al., 2006; Meijer, de Groot, van Gerven, van Boxtel, & Jolles, 2009). Moreover, the relationship between processing speed and performance on cognitive tasks becomes stronger with age (Chen & Li, 2007; Deming, Chang, Tianyong, & Guiyun, 2003; Salthouse & Pink, 2008). Changes in processing speed likely influence many of the cognitive declines associated with aging.

Why does cognitive processing slow with age? Changes in the brain underlie reductions in processing speed. The loss of white matter and myelinated connections reduces processing speed (Bennett & Madden, 2014; Nilsson, Thomas, O’Brien, & Gallagher, 2014). In addition, the loss of neurons forces the remaining neurons to reorganize and form new, often less efficient, connections (Johnson & Rybash, 1993). Another explanation posits a loss of information with each step in cognitive processing. With age, cognitive resources decline and adults show more information loss with each step in cognitive processing; as a result, when attempting a complex task, they perform more poorly than do young adults (Deming et al., 2003; Salthouse & Madden, 2013).

Although clearly apparent in laboratory tasks and highly reliable, the decline in the speed of processing is not as apparent in everyday situations. Middle-aged and older adults proficiently engage in complex tasks every day, showing performance similar to, or better than, that of younger adults. For example, one study tested 19- to 72-year-olds on two tasks: a reaction time task and a typing task. Both tasks measured their speed and accuracy. Although the middle-aged and older adults displayed slower reaction time as compared with young adults, their typing speed and accuracy was no different (Salthouse, 1984). With age, adults compensated for their slower reaction time by looking further ahead in the material to be typed, thereby anticipating keystrokes (Bosman, 1993; Salthouse, 1984). As they age, adults compensate for limitations in processing speed by modifying their activities to emphasize skills that rely on accumulated knowledge and thereby honing their crystallized intelligence (Bugg, Zook, DeLosh, Davalos, & Davis, 2006; Salthouse, 1996).

**EXPERTISE, PROBLEM SOLVING, AND WISDOM**

Over the course of midlife into old age, adults gain experience and knowledge. As a result, they demonstrate advances in practical problem solving in which they apply their experience and expertise to achieve goals and solve problems in the real world. Adults also gain emotional maturity as they become better able to regulate their emotions and focus on what is appropriate in a given context. These abilities are related to what is often called wisdom, a practical sense of insight or understanding how life can be most meaningful. Let’s examine these qualities.

**Expertise**

With age, most adults develop and expand their expertise, an elaborate and integrated knowledge base that underlies extraordinary proficiency in a given task and supports gains in practical problem solving. The development of expertise peaks in middle
adulthood, when experts are able to solve problems efficiently by using abstract reasoning and making intuitive judgments. Experts are not distinguished by extraordinary intellect but by knowledge and experience (Ericsson, 2014).

It is expertise that enables middle-aged and older adults to compensate for declines in processing speed and memory (Ericsson & Moxley, 2013), like the typists who compensated for declines in reaction time by looking further ahead in the material to be typed (Salthouse, 1984). One study of food service workers found that gains in expertise compensated for declines in physical performance. In this study, 20- to 60-year-old food service workers were compared on several aspects of expert performance: strength and dexterity, technical knowledge (e.g., of the menu), organizational skills (e.g., setting priorities), and social skills (e.g., providing professional service). Although middle-aged workers showed declines in physical abilities, they performed more efficiently and competently than did young adults, suggesting that expertise in other areas compensated for losses in strength and dexterity (Perlmutter, Kaplan, & Nyquest, 1990).

Expert knowledge is transformative in that it permits a more sophisticated approach to problem solving than that used by nonexperts. Expert thought is intuitive, automatic, strategic, and flexible (Ericsson, 2014). Experts rely on their past experience and evaluation of the context in determining their approach. With experience, experts’ responses become automatic—well rehearsed, seemingly without thought. They operate on hunches—intuitive judgments of how to approach a problem based on experience. This automaticity enables them to process information more quickly and efficiently, and it makes complex tasks routine (Herzmann & Curran, 2011). As expertise grows, experts find that their responses become so autonomic that it is hard for them to consciously explain what they do. For example, adults are better than children at tying shoelaces, yet children are far better than adults at explaining how to tie shoelaces (McLeod, Sommerville, & Reed, 2005).

In addition to operating more intuitively and automatically, expert behavior is strategic. Experts have a broader range of strategies and have better strategies than novices and can better apply them in response to unanticipated problems (Ericsson & Moxley, 2013). Despite showing slower working memory, experts maintain their performance in their areas of expertise, often by relying on external supports, such as notes (Morrow & Schriver, 2007). For example, one study presented airplane pilots with a flight simulation. They were given directions from air traffic controllers and allowed to take notes. The experienced pilots were more likely to take notes than the nonexpert pilots, and their notes tended to be more accurate and complete (Morrow et al., 2003). In actual flights comparing pilots ages 22 to 76, older pilots take more notes than do younger pilots but do not differ in their ability to repeat complex instructions regarding flight plans and conditions (Morrow et al., 2003). Similarly, expert golfers show fewer declines in performance with age as they compensate for their changing capacities (Logan & Baker, 2007). Longitudinal research with expert chess players showed few age effects in chess skill (Moxley & Charness, 2013); players with greater expertise and participation in tournaments showed fewer age-related declines in chess performance but performed similarly in other measures of cognition (Roring & Charness, 2007).

Finally, intuitive and automatic application of a broad range of strategies permits experts to be more flexible than novices. Experts are more open to deviating from formal procedures when they encounter problems. Experts often approach cases in an individualized way, varying their approach with contextual factors, and are sensitive to exceptions (Ormerod, 2005).

Expertise permits **selective optimization with compensation**, the ability to adapt to changes over time, optimize current functioning, and compensate for losses in order to preserve performance despite declines in fluid abilities (Baltes & Carstensen, 2003; Baltes & Baltes, 1990). As people age, they select aspects of functioning to optimize and improve their proficiency. Typically these are areas in which they excel. People spend effort increasing their expertise in their chosen areas, thereby optimizing their strengths (Bugg et al., 2006; Salthouse, 1984). In addition to emphasizing their strengths, people...
naturally devise ways of compensating for declines in physical functioning and fluid ability. Selective optimization with compensation occurs naturally, often without individuals’ awareness as their expertise permits them to adapt to developmental changes. Older typists who look further ahead in their typing and experienced pilots who take more detailed notes are examples of expertise compensating for declines in working memory and processing speed. Successful aging entails selective optimization with compensation (Freund & Baltes, 2007).

**Problem Solving and Wisdom**

Cognitive changes in older adulthood are also reflected in problem-solving skills. As we have seen in the preceding sections, cognitive functioning—including processing speed, episodic memory, executive functioning, and verbal ability—typically declines in older adulthood, and this trend is closely related to problem-solving ability (Burton, Strauss, Hultsch, & Hunter, 2006). Laboratory studies of problem solving that rely on traditional hypothetical problems show declines with age, likely because of memory changes that make it difficult for older adults to retain and manipulate the information needed to solve the problem (Sinnott, 2003). Yet when decisions tap into relevant experience or knowledge, older adults tend to be as effective at making decisions as younger adults (Denney, Pearce, & Palmer, 1982).

Moreover, examinations of problem-solving skills in everyday settings show that people remain efficient decision makers throughout adulthood. For example, older adults tend to show adaptive problem solving in response to health-related decisions; they are actually better than younger adults at making decisions about whether they require medical attention and seeking medical care (Artistico, Orom, Cervone, Krauss, & Houston, 2010; Lökkenhoff & Carstensen, 2007; Thornton & Dumke, 2005). In one study, the quality of reasoning behind decisions of 60- to 74-year-olds and 75- to 85-year-olds did not differ from that of college students, but older adults processed the problems more slowly (Ratcliff, Thapar, & McKoon, 2006).

Generally speaking, adults perform better on everyday problems that are relevant to the contexts they experience in their daily lives (Artistico et al., 2010). Specifically, older adults outperformed young and middle-aged adults on problems set in older adult contexts, such as medical care, suggesting that age-related declines observed in laboratory settings may not be observed in everyday life. In addition, older adults are more likely to act efficiently and decisively in solving problems that they feel are under their control (Thornton & Dumke, 2005). Research suggests that older adults are better at matching their strategies to their goals than are young adults, perhaps because past experience and crystallized knowledge provide an extensive base for making real-life decisions and aligning goals with decisions (Hoppmann & Blanchard-Fields, 2010). Finally, older adults are more likely than younger people to report that they turn to spouses, children, and friends for input in making decisions (Strough, Patrick, & Swenson, 2003).

Related to everyday problem solving, it is commonly thought that older adults become wiser with age. *Wisdom* refers to “expertise in the conduct and meanings of life,” characterized by emotional maturity and the ability to show insight and apply it to problems (Baltes & Kunzmann, 2003; Staudinger, Kessler, & Dörner, 2006). It requires knowledge, not in the “book smarts” sense, but the ability to analyze real-world dilemmas in which clean and neat abstractions often give way to messy, disorderly, conflicting concrete interests (Birney & Sternberg, 2011). Wisdom requires metacognition, being aware of one’s thought process, creativity, and insightfulness.

The belief that age brings wisdom is reflected in many societies’ respect for older adults as society elders and leaders. Research, on the other hand, shows variability in the extent to which older adults actually display wisdom (Karelitz et al., 2010). In typical studies examining wisdom, adults aged 20 to 89 respond to hypothetical situations reflecting uncertain events, such as what to do if a friend is contemplating suicide (Staudinger, Dörner, & Mickler, 2005). Researchers rate each response for the degree...
Informed Consent in Older Adulthood

A cornerstone of modern medicine is the recognition of patients' rights to provide informed consent to participate in research or treatment. Informed consent requires that the patient have knowledge and the ability to understand information about any proposed procedures, understand that participation is voluntary, and be able to make a reasoned decision of whether to engage. Many conditions common to older adults, such as dementia, slowly rob older adults of their capacities to engage in the reasoning and decision making that is essential to providing informed consent.

To assess basic cognitive capacities, a caregiver may ask the patient questions about the date, year, and surroundings. A respondent who demonstrates a lack of awareness of such basic matters would likely be considered unable to engage in decision making (Purohit & Kalairajah, 2010). In one sample of older adults in residential living facilities, the best predictors of the incapacity to provide informed consent were cognitive impairments, impairments in activities of daily living, and dementia diagnosis. Only about one-third of those studied were able to meet requirements to provide informed consent (Black et al., 2008). Those who live in residential facilities, however, are more likely to be ill or suffer from dementia than older adults who live independently in the community.

A study of older adults' abilities to consent to medical procedures showed that cognitive scores were positively related to the length of physicians' visits and length of consent discussions: Physicians spent less time discussing procedures with patients who had lower cognitive scores, presumably because these patients had less involvement in decision making (Sugarman et al., 2007). As cognitive impairment increased, patients engaged less in conversations between the physician and the patient's companion, from whom the physician was soliciting consent. When patients spoke, they primarily agreed with and approved of what was said. Although at first this might seem to signal consent, for persons with dementia, such an interpretation should be made with caution. Because affirming statements may simply be a means of engagement rather than a deliberate cognitive act, it is difficult to assess the patient's actual preference. Multiple exposures to information are helpful in enabling ill older adults to comprehend and reason with it. Thus, communicating with patients and soliciting consent is best practiced as a process rather than a one-time event (Purohit & Kalairajah, 2010).

An important alternative to consent is soliciting geriatric assent, which balances the process of engaging patients in decision making with protecting them from harm. Geriatric assent takes into account older adults' remaining capacity for autonomous decision making. Physicians identify the patient's longstanding values and preferences, assess plans of care accordingly, and protect patients' remaining autonomy. Many patients with dementia can still express their values and preferences, even when they remain irreversibly below thresholds of decision-making autonomy. Geriatric assent does not encourage incompetent persons to make decisions that are beyond their capacity, thereby placing them in harm's way, but instead permits older adults to have a say in their care for as long as they are able (Molinari, McCullough, Coverdale, & Workman, 2006).

What do you think?

What factors (cognitive or otherwise) do you think are most important contributors to older adults' capacities to make medical decisions? Under what conditions should an older adults' competence be evaluated?

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Lives in Context

• Informed Consent in Older Adulthood

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To which it illustrates several components of wisdom: knowledge about fundamental concerns of life such as human nature, strategies for applying that knowledge to making life decisions, ability to consider multiple contextual demands, and awareness and management of ambiguity, in that many problems have no perfect solutions. A small number of adults at all ages scored high in wisdom; they had experience in dealing with human problems, such as that which is obtained in human service careers or in leadership roles (Staudinger & Baltes, 1996; Staudinger et al., 2006). When both age and experience were
taken into account, older adults were, indeed, more likely to show wisdom than were younger adults. In another study, however, only college-educated older adults scored higher on measures of wisdom than did college students, suggesting that wisdom does not necessarily come with age, but rather with the opportunity and motivation to pursue its development (Ardelt, 2010).

Wisdom is especially likely to be shown when considering problems that are most relevant to individuals. For example, in one study younger and older adults completed traditional measures of wisdom (hypothetical dilemmas), and they were asked to discuss problems relevant to young adults, specifically, marital conflict. Marital conflict problems were presented in written vignettes and in video clips. There were no age differences in the traditional wisdom task, but in the marital conflict tasks the young adults gave responses more indicative of wisdom than did the older adults. It appears that relevance matters—age differences in wise reasoning about fundamental life issues depend on relevance of problems (Thomas & Kunzmann, 2014).

Life experience, particularly facing and managing adversity, contributes to the development of wisdom. One study of people who came of age during the Great Depression of the 1930s found that, 40 years later, older adults who had experienced and overcome economic adversity demonstrated higher levels of wisdom than their peers (Ardelt, 1998). Experience, particularly expertise in solving the problems of everyday life, is associated with wisdom (Baltes & Staudinger, 2000). Those who are wise are reflective; they show advanced cognition and emotional regulation skills. These qualities contribute to the development of wisdom, but they also are associated with better physical health, higher levels of education, openness to experience, positive social relationships, and overall psychological well-being, all of which aid adults in tackling the problems of everyday life (Kramer, 2003).

What can we conclude about wisdom? Perhaps that it is a rare quality, one that can be found at all ages but that typically improves with age. And, older adults are more likely to be among the very wise.

**INFLUENCES ON COGNITIVE CHANGE IN ADULTHOOD**

We have seen that cognition changes in several ways with development. Aspects of cognition that rely on fluid intelligence decline in older adulthood, but those that rely on crystallized intelligence, accumulated knowledge, and experience remain the same or improve. A decline in processing speed, influenced by neurological changes, also influences fluid intelligence and older adults’ ability to take in, process, and retain information (Finkel, Reynolds, McArdle, & Pedersen, 2007; Fry & Hale, 1996). Therefore, aspects of cognition that rely on fluid intelligence decline in older adulthood, but those that rely on crystallized intelligence, accumulated knowledge, and experience remain the same or improve. Cognitive abilities tend to remain stable, relative to peers, over the lifespan. For example, high intelligence early in life (e.g., at age 11) is predictive of intelligence in old age (through age 87; Gow, Corley, Starr, & Deary, 2012). However, with advancing age comes greater diversity in cognitive ability. Centenarians (people aged 100 or older) show greater variations in cognitive performance than do older adults aged 85 to 90 (Miller et al., 2010; Paúl, Ribeiro, & Santos, 2010). Differences in experience and lifestyle can account for many differences in cognitive change over adulthood.

Cross-sectional research shows that education, measured by years of formal schooling or by literacy levels on reading tests, is a strong and consistent predictor of cognitive performance and problem-solving tasks in old age (Kavé, Eyal, Shorek, & Cohen-Mansfield, 2008). In fact, findings from the Georgia Centenarian Study suggest that education accounted for the largest proportion of cognitive differences among the centenarians studied (Davey et al., 2010). Recall from Chapter 1 that cross-sectional and longitudinal studies often yield different results. Similar to research on cognitive change in older adulthood, the influence of education on cognitive change varies depending on whether the
study is cross-sectional or longitudinal (Van Dijk, Van Gerven, Van Boxtel, Van Der Elst, & Jolles, 2008). Longitudinal research studies with older adults from Germany, Australia, and the United States, spanning 7 to 13 years in length with testing occurring at 3 to 6 time points, do not find a relationship between education and cognitive decline at older age (Anstey et al., 2003; Van Dijk et al., 2008). The effects of education are debated, but it is generally recognized that throughout life, cognitive engagement—through mentally stimulating career, educational, and leisure activities—predicts the maintenance of mental abilities (Bielak, 2010; Schaie, 2013).

Another predictor of cognitive performance and impairment across the lifespan is physical health (Blondell, Hammersley-Mather, & Veerman, 2014; S. Wang, Luo, Barnes, Sano, & Yaffe, 2014). Health conditions such as cardiovascular disease, osteoporosis, and arthritis are associated with cognitive declines (Baltes & Carstensen, 2003; Okonkwo et al., 2010). Longitudinal studies also suggest that poor mental health, such as depression and anxiety, is associated with declines in processing speed, long-term memory and problem solving (Lönnqvist, 2010; Margrett et al., 2010). It is difficult to disentangle the directional effects of health and cognitive decline, however, because people who score higher on cognitive measures are more likely to engage in health-promoting behaviors. Physical health and cognitive functioning intersect when it comes to the question of obtaining informed consent from elderly patients requiring various medical treatments, as discussed in the Lives in Context: Informed Consent in Older Adulthood feature.

Interventions that train older adults and encourage them to use cognitive skills can preserve and even reverse some age-related cognitive declines. One study of participants in the Seattle Longitudinal Study examined the effects of cognitive training on cognitive development in older adulthood (Schaie, 2013). Older adults were administered 51 hours’ worth of guided practice completing test items similar to those on a mental ability test and then were tested on two mental ability tests. Two-thirds of adults showed gains in performance, and 40% of those who showed cognitive decline prior to the study returned to their level of functioning 14 years earlier. Training improved strategy use and performance on verbal memory, working memory, and short-term memory tasks. Most promising is that 7 years later, older adults who had received training scored higher on mental ability tests than their peers. In other research, training improved measures of processing speed and fluid intelligence and these improvements were retained over an 8-month period (Borella, Carretti, Riboldi, & De Beni, 2010). Older adults’ improvement with intervention is often similar in magnitude to that of younger adults, including gains in working memory, sustained attention, and fewer complaints about memory (Brehmer, Westerberg, & Bäckman, 2012). Other research suggests that gains from working memory interventions generalize to other measures of fluid intelligence (Stepankova et al., 2014). One meta-analysis concluded that working memory and executive functioning training leads to large gains in the trained tasks and large transfer effects to similar tasks measuring the same construct as the trained tasks. There were also clear but smaller transfer effects for different cognitive abilities than those tested. Overall, it seems that generalization takes place in people of all ages who receive cognitive training (Karbach & Verhaeghen, 2014).

However, this should be taken with caution. One meta-analysis of 87 studies of working memory training found immediate transfer right after training on measured tasks—but these improvements were short term and specific. They did not transfer to other cognitive skills, nor did they generalize to real-world cognitive skills (Melby-Lervåg, Redick, & Hulme, 2016)

Although older adults experience cognitive declines, there is a great deal of variability in everyday functioning. It is possible to retain and improve cognitive skills in older adulthood. The challenge is to encourage older adults to seek the experiences that will help them retain their mental abilities. Older adults who maintain a high cognitive functioning tend to engage in selective optimization with compensation: They compensate for declines in cognitive reserve or energy by narrowing their goals and selecting activities that will permit them to maximize their strengths and existing capacities. In all, healthy older adults retain the capacity to engage in efficient controlled processing of information.
Thinking in Context 7.5

1. Consider the cognitive changes that occur over the lifespan. In your view, are cognitive development, reasoning, and decision making best described as developing continuously or discontinuously? (Recall these concepts from Chapter 1.) Why?

2. An important theme of lifespan development is that development is characterized by gains and losses. How might the cognitive changes that adults experience illustrate this?

3. What factors might make older adults better decision makers than young adults? Worse?

4. Consider the lifespan development principle that domains of development interact. How might cognitive changes influence other areas of development in adulthood, such as emotional and social development? How might the reverse be true?

Apply Your Knowledge

Professor Martell was interested in fostering cognitive ability in children, adolescents, and adults. He began by consulting with a local elementary school.

1. What information would he need to know about the children? What should he measure?

2. What aspects of cognition are the most important to target? Why?

3. How might he intervene? What kinds of activities or assignments might help?

4. How will he know if the intervention worked?

When considering adolescents, Professor Martell decided that he was most interested in helping them to make good choices and behave responsibly.

5. What aspects of cognitive development should he measure? Why?

6. What kinds of activities might he suggest to teachers? How should he intervene to help adolescents?

7. How will he know if the intervention worked?

Professor Martell decided that adults need access to accurate information about cognitive aging.

8. What do adults need to know about cognitive change?

9. What would you tell adults about the aging process, influences on cognitive aging, and the effects of cognitive aging on everyday functioning?

10. What sort of activities or interventions might Professor Martell suggest to adults?
CHAPTER 7 IN REVIEW

7.1 Identify the parts of the information processing system and its function over the lifespan.

**SUMMARY**
The information processing perspective views the mind as composed of three mental stores: sensory register, working memory, and long-term memory. From infancy to late adulthood, information moves through these stores and we use these three stores to manipulate and store it. With development, we get better at moving information through our cognitive system in ways that allow us to adapt to our world.

**KEY TERMS**
sensory memory  
attention  
working memory  
central executive  
long-term memory  
executive function

**REVIEW QUESTIONS**
1. What are the three parts of the information processing system?
2. How does each part function?
3. How does the information processing system change with age?

7.2 Describe developmental changes in infants’ capacities for attention, memory, and thought.

**SUMMARY**
Infants display attention and memory at birth. They show more attentiveness to dynamic than static stimuli and their attention and memory develop over time. Infants are most likely to remember events when they are actively engaged and in familiar contexts, as well as when the events are emotionally arousing. Infants naturally categorize objects, permitting them to store and retrieve memory and respond with familiarity to new stimuli from a common class. As early as 7 months of age, infants use conceptual categories based on perceived function and behavior.

**KEY TERM**
categorization

**REVIEW QUESTIONS**
2. What is classification and how does it change over infancy?

7.3 Describe developmental changes in children’s capacities for attention, memory, and thought.

**SUMMARY**
Steady increases in central executive function and working memory occur throughout childhood. One reason why young children perform poorly in recall tasks is that they are not very effective at using memory strategies. Episodic memory develops steadily from 3 to 6 years of age, through adolescence, and is accompanied by increases in the length, richness, and complexity of recall. The way adults talk with the child about a shared experience can influence how well the child will remember it. Between the ages of 2 and 5, children’s understanding of the mind grows. In early childhood, children become capable of understanding that people can believe different things, that beliefs can be inaccurate, and that sometimes people act on the basis of false beliefs. Children thereby become able to lie or use deception in play. Children’s performance on false-belief tasks is closely related with language development, interaction with others, and measures of executive function. Advances in metacognition accompany prefrontal development and enable school children to view the mind as an active manipulator of information, become mindful of their thinking and better able to consider the requirements of a task, determine how to tackle it, and monitor, evaluate, and adjust their activity to complete tasks.

**KEY TERMS**
selective attention  
memory strategies  
episodic memory  
recognition memory  
recall memory  
scripts  
avtobiographical memory  
infantile amnesia  
topy of mind  
metacognition  
false-belief task  
metamemory

**REVIEW QUESTIONS**
1. How does attention improve during childhood?
2. What are some reasons why working memory improves?
3. What are three examples of gains in long-term memory?
4. When does metacognition develop? What is its role in thinking?

7.4 Explain how advances in brain development during adolescence influence memory, metacognition, and scientific reasoning.

**SUMMARY**
Connections between the prefrontal cortex and various brain regions strengthen, improving attention and working memory and permitting rapid communication and enhanced cognitive and behavioral...
functioning. With these advances in brain development, routine decisions become automatic, enabling adolescents to redirect their thinking toward more complicated problems. Advances in response inhibition enable adolescents to adapt their responses to the situation. Working memory reaches adult-like levels by about age 19 and continues to improve into the 20s. Metacognition improves during adolescence and the reflection that accompanies it plays an important role in the development of scientific reasoning. Although adolescents show advances in scientific reasoning, their reasoning tends to emphasize single solutions to problems. The difference in maturational timing between the limbic system and prefrontal cortex means that adolescents feel emotionally charged before they have corresponding self-regulation and decision-making abilities, often leading to poor decisions.

REVIEW QUESTIONS
1. What key changes occur in attention, working memory, and thinking during adolescence?
2. What is the role of brain development in these cognitive advances?

7.5 Compare patterns of change in working memory, long-term memory, problem-solving capacities, and wisdom in adulthood.

SUMMARY
With age, it becomes more difficult to divide attention to engage in two complex tasks at once and focus on relevant information as well as to inhibit irrelevant information. The capacity of working memory declines over the adult years because of a decline in sensory capacity, attention, and the use of memory strategies. Speed declines from early adulthood through the middle to late adult years. An expanding knowledge base and growing expertise permits most adults to show few changes in cognitive capacity within everyday contexts and compensate for declines in processing speed. People remain adaptive problem solvers throughout adulthood. Adults perform best on everyday problems that are relevant to the contexts they experience in their daily lives. With age adults are more likely to report turning to spouses, children, and friends for input in making decisions. Wisdom does not necessarily come with age, but rather with the opportunity and motivation to pursue its development. Experience, particularly expertise in solving the problems of everyday life, is associated with wisdom.

Older adults who maintain a high cognitive functioning tend to engage in selective optimization with compensation. They compensate for declines in cognitive reserve or energy by narrowing their goals and selecting activities that will permit them to maximize their strengths and existing capacities.

KEY TERMS
- expertise
- proactive interference
- selective optimization with compensation
- wisdom

REVIEW QUESTIONS
1. How do attention and working memory typically change over adulthood?
2. What cognitive advances compensate for information processing declines?
3. What age-related changes can the typical adult expect in terms of problem solving?

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- Videos and multimedia content to enhance your exploration of key topics