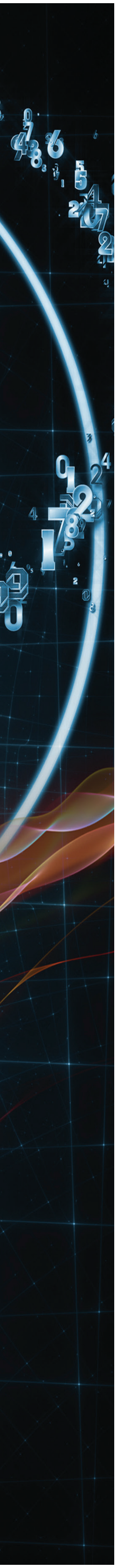


Chapter 9

Current Perspectives on Cognitive Development and Decline

OUTLINE

"Memories, even bittersweet ones, are better than nothing."

Jennifer L. Armentrout

While Piaget viewed cognitive development as occurring through qualitatively distinct stages, information-processing theories view cognitive development as continuous, during which specific processes increase in efficiency to a certain point, and then—perhaps—decline. In this chapter, we will discuss developmental changes in various aspects of information-processing and executive functions. Attention, memory, and metacognition are some of the topics discussed here. We will also explain how learning and knowledge change across childhood.

9.1 Cognitive Development and Decline—Current Perspectives

LEARNING OBJECTIVES:

1. Discuss how attention changes throughout the life span
2. Describe the various types of memory and how they change across the life span
3. Explain what theory of mind is and why it is important
4. Understand the components of intelligence and how they change during adulthood
5. Explain the important tasks of selection, optimization, and compensation.
6. Understand what is meant by metacognition and how it develops
7. Explain academic skill development across childhood

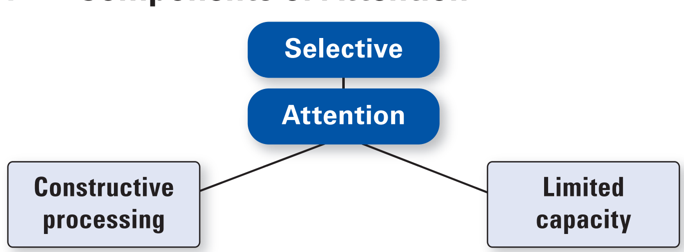
9.1a *Attention and Memory*

Attention

Attention is defined as "the concentration of awareness on some phenomenon to the exclusion of other stimuli" (McCallum, 2015). It is selective, involves constructive processing, and has limited capacity (see Figure 9–1) (Flavell, Miller, & Miller, 2002). Infants display the beginnings of understanding attention through shared gazes. "Maintaining attention to faces and voices of people speaking is critical for perceptual, cognitive, social, and language development" (Bahrick, Todd, Castellanos, & Sorondo, 2016, p. 1705).

Attention
Concentrating on a specific phenomenon to the exclusion of other stimuli

Figure 9–1 Components of Attention



While preschool children have some understanding of attention, it is limited. They often fail to understand that attention is selective. Instead, they often assume that adults will be able to attend to and process any information in the vicinity.

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Young children have limited attention.

Compared to preschoolers, school-age children have a better understanding of attention (Flavell, Miller, & Miller, 2002; Galotti, 2017). They understand that attention is selective and requires processing. They are also able to distinguish between attention and comprehension. **Sustained attention** is the ability to direct one's attention and focus to a specific stimulus (Jacknicke, 1995). There is rapid growth in the ability to sustain attention between the ages of 5 and 9 (Betts, McKay, Maruff, & Anderson, 2006). After that, growth levels off with small improvements into adulthood. Figure 9–2 shows the three stages for sustained attention.

Figure 9–2 Three Stages for Sustained Attention

Beyond understanding attention and sustained attention, school-age children possess better attention skills. It is difficult to process information and store it in memory without paying adequate attention. Young children have short attention spans, partly because they are easily distracted (Kaplan, 1990). School-age children show considerable improvement in this area (Flavell, 1985; Flavell, Miller, & Miller, 2002; Galotti, 2017). Their greater ability to differentiate their attention—that is, to determine the relevance of something—comes partially from instruction by parents and teachers (Small, 1990) and partially from brain development, including myelination.

To perform learning activities, school-age children show improvements in another important cognitive skill: **selective attention** (Enns & Girgus, 1985; Galotti, 2017; Maccoby & Hagen, 1965). This involves tuning out distracting stimulations when performing a particular task. For example, second-grade children find it hard to concentrate on a task while music is playing (Higgins & Turnure, 1984). Sixth-grade children are not so bothered by music in performing the same task. Adolescents may be able to handle even more complex distractions.

> ? How is attention understood during early and middle childhood?

In contrast to selective attention, there is also divided attention, more commonly referred to as multitasking. **Multitasking** is defined as the ability to distribute one's "attentional resources over multiple tasks" (Scholey et al.,

Sustained attention
The ability to direct one's attention and focus to a specific stimulus

Selective attention
A cognitive ability to tune out distracting stimulation while performing a task

Multitasking
The ability to distribute one's attentional resources over multiple tasks

2014, p. 435). Multitasking is cognitively more demanding than focusing attention on one task. Research has shown that the ability to multitask grows each year between the ages of 7 and 12 (Yang et al., 2017). The development of memory and the ability to plan support the development of multitasking. Practicing allows children to improve their ability to plan, which also helps improve multitasking. All aspects of attention develop as the brain continues to develop into early adulthood.

Selective and multitasking skills peak in adulthood and begin to show decline towards the latter part of middle adulthood. Another cognitive process that decreases during adulthood is mind-wandering. **Mind-wandering** (MW) is defined as "the phenomenon of attention shifting away from mental contents related to the task at hand to unrelated thoughts and feelings" (Gyurkovics, Balota & Jackson, 2018, p. 89). Is MW necessarily a bad cognitive process? No, it is actually a healthy cognitive process. One study found that engaging in MW can actually increase one's ability to pay attention, at least in nature. Spending time in nature allows one the opportunity to both pay attention to the beauty of nature, as well as the time to allow one's mind to wander. Engaging in these cognitive processes further strengthen neural pathways, resulting in an increase in creativity and the ability to control one's sustained attention (Williams et al., 2018). Hence, a decrease in MW is perceived as a negative outcome of aging. It is proposed that the decline in MW during older adulthood is related to an overall decline in cognitive resources (Gyurkovics, Balota & Jackson, 2018).


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Mind-wandering when driving can be dangerous.

While MW has benefits, it also can have some risks associated with it. One study found that MW while driving results in faster speed, which places one at risk for accidents (Albert et al., 2018). MW is not the only thing that can increase risky driving. One interesting question concerns whether there a difference in attention and driving ability if a conversation is occurring between two people in the vehicle (passenger conversations) or if a conversation is occurring on a cell phone (cell phone conversations) (Drews, Pasupathi, & Strayer, 2008). Research findings indicate that driving errors are lower for those engaged in passenger conversations than for those in cell phone conversations. The proposed explanation for this is that when two conversing individuals are in the same vehicle, they have a shared attention and awareness for the traffic and road conditions. This allows for conversation to ebb and flow as needed for the driver. This research helps explain why cell phone conversations quadruple the risk of driving accidents (McEvoy et al., 2005), while the risk of an accident decreases when there is another adult in the vehicle besides the driver (Rueda-Domingo et al., 2004).

Finally, just aging can lead to risky driving behavior. We spoke about a decline in eyesight in a previous chapter, which plays a factor. However, cognitive processing changes also play a factor. One study of drivers ages 70–88 assessed "visual attention, processing speed, inhibition, reaction time, and task-switching" (Anstey & Wood, 2011, p. 613). **Visual attention** assesses the participant's ability to use their vision to selectively pay attention to important visual cues, in this case, while driving. Processing speed, or **speed of processing**, accesses how quickly your brain can process information. **Inhibition** is defined as "the interference

Mind-wandering
The phenomenon of attention shifting away from mental contents related to the task at hand to unrelated thoughts and feelings

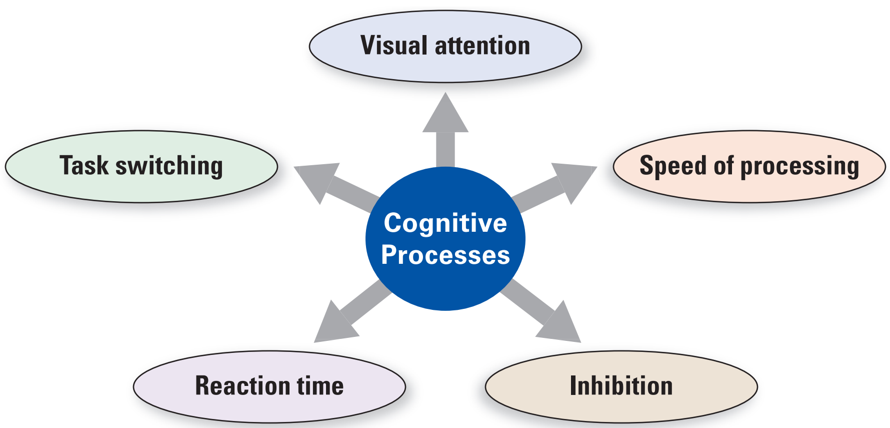
Visual attention
Assesses the participants' ability to use their vision to selectively pay attention to important visual cues

Speed of processing
Accesses how quickly your brain can process information

Inhibition
The interference with or prevention of a behavioral or verbal response even though the stimulus for that response is present

with or prevention of a behavioral or verbal response even though the stimulus for that response is present" (National Center for Biotechnology Information, n.d.). In this case, could the participants respond appropriately to visual cues when driving (e.g., slowing down when seeing red brake lights ahead)? **Reaction time** refers to how long it takes to make appropriate behavioral changes based on some stimulus in the environment. For example, a person knows that they need to brake, so how long does it then take for the foot to move from the gas to the brake pedal and apply pressure? Finally, **task switching** is the ability to move one's attention from one task to another. In the study by Anstey and Wood (2011), researchers found that errors in all of these processes increased with age. Further, errors in visual attention, processing speed, inhibition, and task-switching increased the likelihood of driving errors; only reaction speed was unrelated to driving errors. Hence, while vision changes make driving more challenging in later adulthood, so do cognitive changes.

Figure 9–3 Cognitive Processes Affected by Age



Speed of processing and the ability to control what one pays attention to are vital for daily functioning (Rogers & Fisk, 2001; Tun & Lachman, 2008). As mentioned previously, as the brain ages, speed of processing slows down, but what about attention in general? When attention is assessed globally, attention for *complex tasks* appears to decline over time. However, college-educated adults perform complex attention tasks at levels for individuals who are 10 years younger than them, but uneducated. Stated another way, people who went to college have the attention ability of people 10 years younger. This college-effect persists up to the age of 75 (Tun & Lachman, 2008). However, this was a study focusing on complex attention measured in a global fashion. Is there a way to tease apart aspects of attention, much like there are different aspects of memory? If so, would these different aspects show the same effects with aging, or differ?

There is evidence to suggest that there are at least two systems devoted to attention in the brain: the posterior attention system and the anterior attention system (Posner & Peterson, 1990). The **posterior attention system** includes brain areas such as the posterior parietal cortex and the thalamus (Posner, 1995). This attention system appears to be important for being able to pay attention to visual information, particularly visual space. The **anterior attention system** includes

Reaction time
The amount of time it takes a person to respond to a stimulus

Task switching
The ability to move one's attention from one task to another

Posterior attention system
Includes the brain areas such as the posterior parietal cortex and the thalamus

Anterior attention system
Includes the brain areas such as the prefrontal cortex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Exercise can slow down both physical and cognitive decline as one ages.

brain areas such as the prefrontal cortex. This attention system appears to be important for being able to direct and choose what a person wants to pay attention to among a multitude of stimuli. Research using both cognitive tasks and electroencephalogram (EEG) recordings seems to indicate that the aging process affects the anterior attention system more than the posterior attention system (West & Bell, 1997). This would mean that older adults maintain their ability to pay attention to and cognitively process visual information, while the ability to focus attention on one particular aspect of a task would show declines.

How do the posterior attention system and the anterior attention system differ in their attentional processes?

Not all news is bad news, however, when discussing attention in old age. Research has explored the relationship between having a sense of control over one's life and cognitive decline with aging (Lachman, 2006). In general, those who have a sense of control over their life during midlife show less cognitive decline during late adulthood. One may ask why this is so. A study by Robinson and Lachman (2018) found that those who have a greater sense of control are more likely to exercise, and exercising slows down cognitive decline. Hence, exercising is not just important for health and slowing down one's physical decline, it is also important for slowing down one's cognitive decline.

PAUSE *&Process*

- What is meant by attention?
- How does attention change across the life span?

Basic processes
Frequently used, rapidly executed memory activities such as association, generalization, recognition, and recall; among the building blocks of cognition, in the sense that all more complex cognitive activities are built by combining them in different ways

Memory
The ability to encode, store, and retrieve information acquired through experiences

Memory

Within the information-processing paradigm, **basic processes** are defined as "frequently used, rapidly executed, memory activities such as association, generalization, recognition, and recall. They are among the building blocks of cognition, in the sense that all more complex cognitive activities are built by combining them in different ways" (Siegler & Alibali, 2004, p. 180). Basic processes are functional at birth, with some functional prenatally. While infants lack knowledge structures, memory strategies, and such, their ability to use basic processes allows them to form and access memories. **Memory** is defined as the ability to encode, store, and retrieve information acquired through experiences. Table 9–1 lists various types of memory that will be discussed throughout this section of the chapter. Refer back to it as needed.

Table 9–1 Types of Memory

Type of Memory	Definition
Explicit memory	Intentional and conscious recollections
Implicit memory	Unconscious memories that influence behaviors
Episodic memory	Conscious recollection of previous events
Autobiographical memory	Recollection of significant personal events
Sensory memory	Information registered by the senses
Short-term memory (STM)	Brief memory of what is paid attention to in the sensory memory
Long-term memory (LTM)	Information from STM that is rehearsed or manipulated in some way and placed into long-term storage
Working memory	A limited capacity memory that is consciously attending to information to allow for thinking, decision-making, and problem-solving
Visual-spatial memory	Memory for anything that can be seen or experienced in space
Auditory memory	Memory for anything that can be heard
Spatial reference memory	A subset of visual-spatial memory, devoted to only the memory of space and direction
Source memory	Memory for where information came from
Semantic memory	General knowledge—like what you learn at school or through your experiences
Procedural memory	Memory of how to complete tasks
Primary short-term memory	The part of STM responsible for keeping information in STM

First, we should distinguish between the basic processes of explicit and implicit memories. **Explicit memories** are memories of which we are conscious. We can typically visualize these memories and provide a verbal account. **Implicit memories** are unconscious memories that influence our behavior. For example, most of you have probably been driving for a while. You do not need to (hopefully) consciously try to remember which pedal is for the gas and which is for the brake. You implicitly know this and this knowledge directs your behavior. This is an example of an implicit memory. However, if you were asked to recount your scariest driving moment, you would verbally relate the story as you consciously extricate it from your memory. This would be an example of an explicit memory. Both types of memory are important; yet, they have their own developmental timetable.

It appears that infants are capable of forming implicit memories from birth, if not prenatally. However, it is not until around 6–8 months that infants seem able to form explicit memories. Evidently, implicit and explicit memories utilize different parts of the brain that mature at different times (Galotti, 2017; Siegler & Alibali, 2004).

Explicit memory
The information that you purposely try to recall, such as when you tell a friend about a movie you just watched

Implicit memory
Unconscious memories that influence our behavior

Association is the most fundamental of basic processes and it is the ability to form a connection between a stimuli and a response. **Recognition** is another basic process. Once again, both of these are certainly present at birth and are most likely present prenatally. Association can be tested through the classical conditioning process discussed in Chapter 2. Recognition has been tested in preterm and full-term infants using the **habituation/ dishabituation** process. For example, newborns like to gaze at novel visual stimuli. Once a stimulus becomes familiar, their gazing time decreases. However, if you present a new, novel stimulus, gazing time increases again. This basic knowledge allows us to test both visual preferences and recognition. Using habituation/dishabituation, we know that 2-month-olds recognize old visual stimuli for more than 2 weeks after initial exposure.

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In the Rovee-Collier experiment, infants learned that kicking would cause a mobile to make sounds.

Have you ever stuck your tongue out at a newborn? I suppose most of you haven't, but guess what would happen if you did? The newborn would stick his or her tongue out at you in reply. The newborn isn't being rude; instead, they are imitating observed behavior. **Imitation** and **recall** are also basic processes present at birth. Not only is the newborn capable of immediately imitating your behavior, but they still recall the experience 24 hours later. Newborns that have observed tongue protrusion behavior are more likely to engage in such behavior for the 24 hours afterwards than newborns who did not observe such behavior. This pattern holds true not just for tongue protrusion behavior, but also for opening/ closing of mouth behavior. As infants grow older, the amount of time between observation and imitation/recall increases. Shortly after the first birthday, infants can demonstrate imitation and recall over 4 months after the initial observation (Galotti, 2017; Siegler & Alibali, 2004).

Hayne and Rovee-Collier (1995) demonstrated the memory capabilities of infants across a series of experiments utilizing infant mobiles (the circular things that hang above cribs with dangling toys that play music). The researchers would tie a string connected to a mobile to the ankle of an infant. If the infant kicked, the mobile would make sounds. The studies showed that 3-month-olds would experience an "aha" moment in which they would learn that their kicking behavior caused the mobile's noise. Infants were able to recall and generalize their learning across similar situations if comparable experiences were provided within 3 days of each other.

In summary, infants are born with basic processes that allow for quick learning about the surrounding world. These basic processes provide the foundation for all information-processing throughout life.

Researchers study various types of memory beyond just implicit and explicit memories. One type of memory is called **episodic memory**, which "refers to the conscious recollection of specific events that took place at a particular point in time in the past, involving such information as what, where, and when" (Wang, Aydin, & Klemfuss, 2017). One subset of your episodic memory is your **autobiographical memory**, which can be defined as recollections of specific and personal events that are of significance (Holland & Kessinger, 2010). Not every episodic memory becomes part of one's autobiographical memory, just the important ones. For example, what you wore 3 weeks ago on Tuesday is probably not in your autobiographical memory. However, what you wore to your prom, high school graduation, or wedding likely is.

Association
The ability to form a connection between a stimulus and a response

Recognition
Awareness or recollection of having seen something before

Habituation/ dishabituation
An experimental technique that allows researchers to measure recognition in babies

Imitation
The basic process of a newborn being capable of immediately imitating your behavior

Recall
The basic process of a newborn being capable of recalling observed behavior experiences

Episodic memory
Specific life event memories

Autobiographical memory
The recollections of specific and personal events that are of significance

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Important episodic memories, such as what you wore to your prom, high school graduation, or wedding, are more likely to become part of your autobiographical memory.

Infantile Amnesia

Infantile amnesia
The inability to remember much about the first 3 or so years of life after birth

What is your earliest memory? How old are you in this earliest memory? Most of us do not remember much about the first 3 or so years of our life after birth. This is referred to as **infantile amnesia** (sometimes referred to as childhood amnesia). We slowly start to form autobiographical memories around the age of 3–4. The number of memories formed each year increases until the age of 7, when it levels off (Bauer, 2015).

It used to be assumed that infants could not form long-term memories; however, we know that is false now. Experiences at the age of 11 months can sometimes be recalled a year later, showing that semantic and episodic memories are formed and accessible for periods of time; however, autobiographical memories are strangely absent. Why is it that we cannot remember our own birth? Why can't we remember our first steps or piece of birthday cake? These seem like worthwhile memories to keep, so where have they gone?

Some have theorized that a relatively late development of autobiographical memory in early childhood may be the cause of infantile amnesia (Galotti, 2017; Siegler & Alibali, 2004). Others have theorized that infant memories are encoded using the senses, as opposed to language; hence, while these memories may still be stored in the brain, they are inaccessible. A new theory has been proposed by Bauer (2015), in which two complementary processes explain both infantile amnesia as well as the leveling off of autobiographical memory at age 7.

Bauer (2015) proposes that our autobiographical memory improves as our memories become more elaborated and integrated. Further, as our neural, mnemonic, and other cognitive processes improve, our rate of forgetting declines. In other words, Bauer proposes that we experience infantile amnesia because our early autobiographical memories were not part of an integrated system of memories and a lack of brain development sped up the forgetting of these memories. It is an interesting new theory that future research can further examine.

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Infantile amnesia prevents us from remembering significant early events, such as our first birthday.

What are three theories about why we have infantile amnesia?

As autobiographical memory improves significantly between the ages of 3 and 7, so to do other aspects of memory. Memory skills improve considerably during early childhood, partly because of the increasing efficiency of the cerebral cortex in storing information. Young children also show improvements in the strategies they use to place such information into their memory (Chance & Fischman, 1987; Galotti, 2017; Schneider & Bjorklund, 1998; Siegler & Alibali, 2004).


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Rehearsal allows us to remember how to complete tasks and activities more efficiently.

Two strategies are used increasingly and more efficiently by young children to help them place information into their memories. First, they strive to master **classification and categorization skills** to facilitate learning and the use of memory in information-processing. In recalling words, for example, young children may associate words that rhyme ("sun-fun" and "fat-hat") (Rossi & Wittrock, 1971; Schneider & Bjorklund, 1998; Siegler & Alibali, 2004). Second, young children learn by **rehearsal**—by doing or saying something repeatedly. For example, when 3-year-olds are directed to remember where something is hidden, they look more intently, touch the area, and point to it repeatedly (Wellman, Ritter, & Flavell, 1975). Naming objects repeatedly may also assist in the process of memory formation. Parents may quiz a child about what she sees, help her to name it, and ask the child to recall it later (Rosinski, Pellegrini, & Siegel, 1977). Preschoolers especially rely on this method of learning when they receive approval for remembering. They become aware that rehearsal improves their ability to use recall (Fabricius & Cavalier, 1989).

The use of memory to process information has been intensively studied among children. Memory is critical to cognition. Recall allows individuals to compare information newly received with information gained from past experiences. But how do information and experiences become memories that you can remember for a long time?

Researchers know that storage of information in the brain's memory occurs in three phases. First, information is temporarily stored in the **sensory memory** (or sensory register) as it is received from the external world (Galotti, 2017; Hoving, Spencer, Robb, & Schulte, 1978; Siegler & Alibali, 2004). This storage is only for a very brief time, often for less than a second. This form of memory functions at adult levels by the age of 5. If the information in sensory memory is attended to, then the information is passed into **short-term memory (STM)** storage. If the information is not rehearsed or otherwise elaborated upon in STM, then it is forgotten within 15–30 seconds. STM steadily improves from infancy throughout childhood. It reaches adult levels during adolescence (Bauer & Starr, n.d.). If the information in STM is elaborated upon and integrated with other knowledge, it may then be processed into **long-term memory (LTM)**, where it may remain indefinitely.

Classification and categorization skills
The ability to use salient features to place objects or constructs into distinct groups

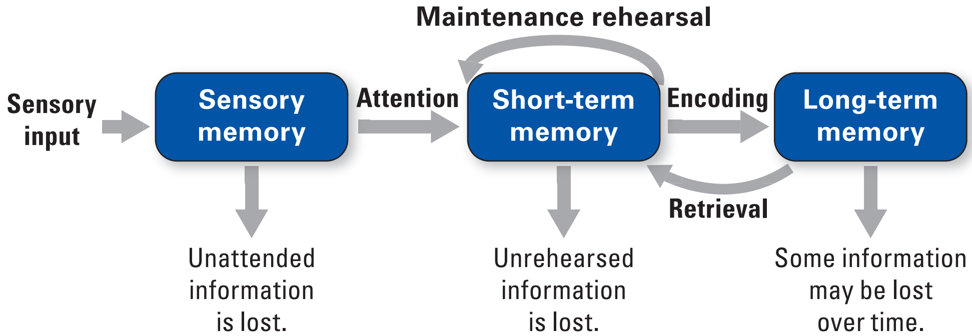
Rehearsal
Practicing something over and over again

Sensory memory
The first memory storage location where sensory information is stored in the brain before becoming short- or long-term memory

Short-term memory (STM)
An initial memory storage location in the brain where information remains for about 1 minute before being erased or placed into long-term memory; recall of information, events, and so on that are relatively recent

Long-term memory (LTM)
The final memory location in the brain where information is stored indefinitely; recall of events in the distant past

Figure 9–4 Basic Memory Processes



Source: Adapted from Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. Spence (Ed.), *The psychology of learning and motivation* (Vol. 2). Oxford, England: Academic Press.

It is well recognized that memory in general improves significantly through middle childhood (Galotti, 2017; Siegler & Alibali, 2004; Williams & Stith, 1980). Memory improvement probably occurs for several reasons, including improvements in attention span, brain development, maturation, and strategies for processing information (Galotti, 2017; Siegler & Alibali, 2004; Wingfield & Byrnes, 1981). In any case, it is known that children discover that verbal strategies assist them to process information into memory (Flavell, Beach, & Chinsky, 1966). Through trial-and-error, they find some strategies work better than others (Justice, 1985).

School-age children typically use repetition and rehearsal to place information into memory (Fabricius & Wellman, 1983; Galotti, 2017). They also use **chunking**, or grouping into one category items that share some attribute. For example, a long list of American presidents may be remembered by grouping all whose last names begin with *B, M,* and *R*. Various other mnemonic devices are used by school-age children to help in memory storage. Learning to spell words in English is a challenge. There are many tried-and-true rules to negotiate the spelling irregularities of English. For example, children find this rhyme very helpful for spelling certain words: "i" before "e" except after "c," or when sounded like "a" as in "neighbor" and "weigh."

Researchers have discovered that one reason school-age children become better at memory retrieval is because of improvements they experience in memory organization. One of the more notable organization methods is to develop **scripts**.

A script is formed out of a series of things that occur repeatedly. Frequently, these are routine events in one's daily life. For example, most people develop a repetitious way for brushing their teeth. Instead of intentionally selecting each step in the process every day, they form a "tooth-brushing script" and use it almost automatically. The steps in the process become unconscious—stored in long-term memory for repeated recall (Nelson & Gruendel, 1981; Slackman & Nelson, 1984).

Many scripts are developed during middle childhood because of children's improved memory and more extensive experiences. These range from the mundane, such as "getting-dressed scripts," to those that have social significance, such as "parenting scripts" and "spouse scripts." The latter scripts are formed through observation of adults in a family system and are not initiated by an individual until needed later in life. Because all scripts are based on learning, they may be modified and changed in any way at any point in the life span. Before

Chunking
Grouping into one category items that share some attribute

Scripts
An organized series of acts committed to memory (e.g., getting dressed, brushing the teeth)

changes can be made, however, a script must be dredged up from the unconscious (Harris & Harris, 1985; Hendrix, 1988; James & Jongeward, 1971).

During adolescence and early childhood, individuals continue to develop new scripts and memory strategies based upon their experiences. Additionally, new knowledge is continually added to long-term memory. While tremendous growth occurs in the various components of memory during childhood, maintenance becomes more important during adulthood. The latter part of middle adulthood is a time when declines begin in some types of memory.

Memory strategies continue to develop and assist with learning.

Working memory is typically conceptualized as the workbench of memory where simultaneous cognitive processes can be attended to and handled (Baddeley, 1986, 1996; Glisky, 2007; Kemper & Mitzner, 2001). It has limited capacity and is the memory that allows for decision-making and problem-solving. There are two branches of working memory: visual-spatial memory and auditory memory. **Visual-spatial memory** involves the memory for colors, shapes, movements, locations—anything that you can see or experience in space. **Auditory memory** (or verbal memory) is memory for everything that you hear. Working memory improves across the life span and peaks during middle adulthood (around age 45) (Swanson, 1999). Declines in working memory begin towards the latter part of middle adulthood (around age 57) and continue to decline in late adulthood (Kemper & Mitzner, 2001; Swanson, 1999). Part of the decline in working memory experienced in middle adulthood is attributed to a general decline in information-processing speed (Chaytor & Schmitter-Edgecombe, 2004; Glisky, 2007). Other theories on decline in working memory point to a decline in attentional resources and a lack of inhibitory control (Glisky, 2007).

Research investigating the impact of hormones on memory is a growing field. The vast majority of this research has focused upon rodent hormones, brain changes, and memory (Galea et al., 2008). The emerging picture is complex, with level of hormones being an important factor, as well as the observation that hormones impact different parts of the brain and different memory processes in diverse ways. To further complicate matters, hormones have differing influences on males and females. There are two interesting findings worth mentioning here. First, the extended use of oral estrogen (like that in birth control pills and hormone replacement therapy) may negatively impact memory. In research on mice, a medium dose of estrogen decreased **spatial reference memory** (or memory for location and space specifically) (Frick & Fernandez, 2003). Conversely, testosterone has been found to increase memory in castrated rats, including reversing spatial reference memory deficits (Khalil, King, & Soliman, 2005). While this research utilized rodents as research subjects, it is clear that hormones may play an important role in memory—or at least some aspects of memory—in humans. Future research will try to tease apart the complex nature of hormone, brain, and memory interactions.

Among the most striking mental changes in late adulthood are those that affect memory (Poon, 1985). Undoubtedly, these changes are frustrating for both older people, and those with whom they interact. A slowing, shrinking brain plays a large role in memory decline.

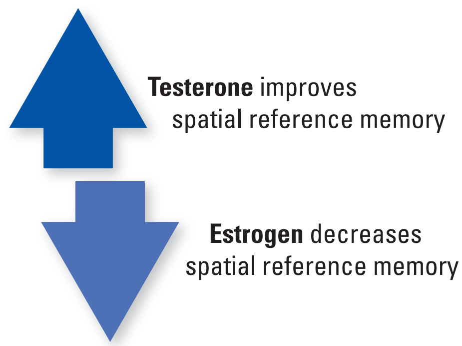
Working memory
The workbench of memory where simultaneous cognitive processes can be attended to and handled

Visual-spatial memory
Memory for colors, shapes, movements, locations

Auditory memory
Also called verbal memory, is memory for everything that you hear

Spatial reference memory
The aspect of memory that stores information about one's environment and spatial orientation

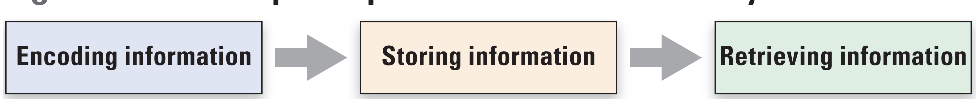
Figure 9–5 Effects of Hormones on Memory



As individuals progress through late adulthood, they have a harder time recalling more recent events in memory, while maintaining the ability to recall information in the distant past. As they advance in age, elderly people may find that they can describe in intricate detail a high-school prom attended 60 years ago, but have difficulty remembering what they had for breakfast that morning.

There may be increasing difficulties with the steps required for processing memory. Usually, three steps are involved in this process: (1) encoding information; (2) storing the information into long-term memory; and (3) retrieving the information for use at a later time. Older people appear to be less efficient in the first step. Encoding is organizing information so that it can be stored in a particular way in the brain (e.g., associating a person's name with an object). Elderly people are also much slower than younger people at retrieving information. Their memory searches take up longer periods of time as they generate and think about alternatives and options. This slowdown is influenced by a person's level of mental activity (Craik, Byrd, & Swanson, 1987), for those who remain intellectually stimulated seem to have fewer problems with retrieving information. Hence, if you want to slow down your own memory decline in old age, stay mentally active (e.g., read, do puzzles, write, etc.). The contributions of an enriched lifestyle to maintaining the neurological aspects of mental functioning cannot be overestimated (Hopson, 1984).

Figure 9–6 Steps Required to Process Memory



Beyond declines in the process of memory, the picture is complex for what specific aspects of memory decline during adulthood. Episodic memory, working memory, source memory, and explicit memory all show declines in late adulthood (Backman, Small, & Wahlin, 2001). **Source memory** is the ability to remember where you heard, saw, or learned something.

However, not all types of memory show declines. **Semantic memory**, or your general knowledge, appears to remain intact. However, it appears that it becomes more difficult to retrieve semantic knowledge in late adulthood (Backman, Small,& Wahlin, 2001). **Procedural memory** is knowledge about how to perform

Source memory
The ability to remember where you heard, saw, or learned something

Semantic memory
General knowledge

Procedural memory
Knowledge about how to perform certain tasks, like riding a bike or driving a car, or even walking

certain tasks, like riding a bike or driving a car, or even walking. This type of memory remains largely unchanged with aging (Backman, Small, & Wahlin, 2001). Implicit memory also appears to remain intact. **Primary short-term memory** is the conscious process of keeping information in short-term memory. This aspect of short-term memory appears to remain stable in late adulthood (Backman, Small, & Wahlin, 2001).

PAUSE *&Process*

- How does memory develop and decline across the life span?
- How are scripts related to memory?

9.1b *Theory of Mind, Problem-Solving, Intelligence, and SOC Theory*

Theory of Mind

A **theory of mind (ToM)** is the ability to understand your own mental state, as well as the mental state of others (Dixon, 2003). "We use ToM to explain and predict our own and others' behavior based on mental states such as beliefs, knowledge, intentions, and desires" (Bernstein, 2018). **Mental state** refers to your thoughts, knowledge, beliefs, and desires. For example, you know that you do not believe in Santa Claus. However, you may know that your 3-year-old niece does believe in Santa Claus. Further, because you know about her beliefs, you may also be able to conjecture her thoughts about Christmas morning. However, a theory of mind takes time to develop.

Henry Wellman has completed a series of studies examining the development of ToM. He has also written numerous articles and chapters describing this phenomenon (e.g., Wellman, 1993; Wellman, 2014; Wellman, 2015; Wellman, Cross, & Watson, 2001; Wellman & Gelman, 1998; Wellman, Kushnir, Xu, & Brink, 2016; Wellman, Lopez-Duran, LaBounty, & Hamilton, 2008, etc.). ToM is dependent on the development of attention skills, language, and other executive function development (Derksen, Hunsche, Giroux, Connolly, & Bernstein, 2018). Around the age of 2, children begin to understand that people have wants and desires. By the third birthday, this understanding grows to include other mental states, such as thoughts and beliefs. At age 4 children really begin to understand the connection between mental states and behaviors. Children are unable to deceive others until they have a theory of mind. While most children fully understand that there is a relationships between mental states and behavior by the age of 4 or 5, children with quality relationships and interactions with older siblings and parents achieve it earlier.

ToM allows for healthy relationships with peers (Derksen et al., 2018). Children with a good ToM are more likely to engage in prosocial behaviors than those with an underdeveloped ToM (Derksen et al.; Imuta, Henry, Slaughter, Selcuk, &

Primary short-term memory
The conscious process of keeping information in short-term memory

Theory of mind
The ability to understand your own mental state, as well as the mental state of others

Mental state
Refers to thoughts, knowledge, beliefs, and desires

Ruffman, 2016). Prosocial behavior includes behaviors such as helping, comforting, and cooperating. This is particularly evident by the age of 6 and beyond.

ToM influences social interactions beyond just prosocial behavior. A naturalistic study examined the influence of ToM on persuasion in children between the ages of 3 and 8 (Slaughter, Peterson, & Moore, 2013). As predicted, ToM influences one's ability to persuade peers to change their mind. Another study assessed ToM between the ages of 6 and 10 and perceived social competence by children's teachers (Devine, White, Ensor, & Hughes, 2016). ToM at the age of 6 predicted social competence at the age of 10. Hence, ToM influences many different aspects of social functioning.

While there is ample research on the development of ToM in children, less is known about ToM in adolescents and adults (Wellman, 2018). Further, researchers have recently begun to argue that ToM is too vague of a term (e.g., Schaafsma, Pfaff, Spunt, & Adolps, 2015). Instead, ToM should be broken down into components so that it is easier to see how ToM changes beyond childhood. A two-component model has emerged, which breaks ToM into two subcomponents: social-perceptual and social-cognitive (Meinhardt-Injac, Daum, & Meinhardt, 2020). The social-perceptual subcomponent involves inferring others' mental states using nonverbal cues, such as body language and facial expressions. The social-cognitive subcomponent involves understanding others' mental states via verbal clues, either through speech or reading (such as text messages). Using the two-component approach allows researchers to examine the intricacies of how ToM further develops beyond childhood.

A recent study examined ToM development between the ages of 11 and 25 using the two-component model (Meinhardt-Injac, Daum, & Meinhardt, 2020). Why this age range? First, as mentioned earlier, very little is known about ToM development beyond childhood. Second, having a ToM is critical for healthy social relationships. In adolescence, there is an increase in the importance of peer social relations. Hence, it is critical to understand how ToM develops during this period when social relationships become front and center.

The study found that the two subcomponents, social-perceptual and social-cognitive, do not follow the same developmental path. The social-perceptual subcomponent increases significantly across adolescence into early adulthood (Meinhardt-Injac et al., 2020). This may be due to an increase in sensitivity of facial expressions during this time. However, the social-cognitive subcomponent levels were unstable, varying greatly across adolescence into young adulthood. The researchers speculated that this may be due to social norms shifting and evolving during this period of life. The study also found that the social-cognitive subcomponent is highly correlated with language and general cognitive development, while the social-perceptual subcomponent had age-related development beyond that of language and general cognitive development. More research is needed to understand the development of ToM across adulthood, looking at these subcomponents.

While little is known about ToM development in adulthood, there is some general research looking at how ToM is related to other psychological processes and characteristics. One study with adults, ranging in age from 18 to 77, found a negative relationship between social anxiety and ToM (Alvi, Kouros, Lee, Fulford, & Tabak, 2020). Said another way, as social anxiety increased, ToM decreased. While cause-and-effect relationships cannot be drawn from correlational research, it is interesting to speculate how struggling to understand the mental states of others is related to one's social anxiety. Another study of older men found that having higher levels of the social-cognitive subcomponent is related to lower levels of loneliness and depressive symptoms (Radecki, Cox, & MacPherson, 2019). Clearly, ToM remains important throughout the life span.

Modern cognitive theorists study ways in which cognitive development continues past childhood. While many areas of information-processing and language skills reach adult-like levels by the end of middle childhood, other areas of cognition continue to develop.

Dialectical Reasoning One area that continues to develop is dialectical reasoning. **Dialectical reasoning** can be defined as "the deliberate coordination of inferences for the purpose of making cognitive progress" (Moshman, 1998, p. 961). In plain English, it involves integrating one's assumptions to assist when reasoning through a problem. Argumentation may involve the use of dialectical reasoning. When debating an issue with another, one will often use their beliefs and observations to make a point.

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As problem-solving develops, children are able to play more challenging games.

Problem-Solving

Problem-solving is another area that shows continued development across childhood into adolescence (DeLoache, Miller, & Pierroutsakos, 1998; Siegler & Alibali, 2004). Problem-solving involves developing a strategy to overcome an obstacle in order to achieve a goal. Problem-solving involves many aspects of cognitive processes, such as memory, reasoning, metacognition, and perception.

One key component to problem-solving is task analysis. **Task analysis** requires you to carefully examine the problem and consider what steps will be necessary in order to solve it (DeLoache, Miller, & Pierroutsakos, 1998; Siegler & Alibali, 2004). After task analysis, you must encode. **Encoding** allows you to develop an internal, mental representation of the situation. Finally, your knowledge should be used to assist in addressing the problem and reconciling it.

There are developmental differences in problem-solving strategies and abilities (DeLoache, Miller, & Pierroutsakos, 1998; Siegler & Alibali, 2004). Rudimentary forms of problem-solving are evident in infancy. Across childhood, the ability to plan a strategy for solving a problem improves. As age increases, the ability to develop and achieve subgoals in assistance to solving the larger problem improves. The ability to choose or develop the most appropriate strategy also improves with age. Finally, with formal operational thought, sophisticated forms of reasoning emerge. Such reasoning allows for better problem-solving.

Intelligence

Intelligence in Early Adulthood Psychologists disagree about the nature of intellectual development in adulthood. There is some evidence that intelligence increases during these years (Bayley & Oden, 1955). Other evidence indicates that intellectual growth peaks in early adulthood and declines thereafter (Bayley,

Dialectical reasoning
The deliberate coordination of inferences for the purpose of making cognitive progress

Problem-solving
The development of strategies to overcome an obstacle in order to achieve a goal

Task analysis
The careful examination of a problem and consideration of what steps will be necessary in order to solve it

Encoding
Developing an internal, mental representation of the situation

1970; Baltes & Schaie, 1974). Developmental psychologists suggest that intellectual functioning changes in four areas during early adulthood: (1) **crystallized intelligence**, or skills acquired through education and socialization (e.g., verbal and mathematical skills, inductive reasoning, and interpersonal skills), becomes more refined; (2) **cognitive flexibility**, or the ability to shift from one thinking style to another, improves; (3) **visuomotor flexibility**, or the ability to shift from familiar to unfamiliar tasks involving hand-eye coordination, improves; and (4) **visualization**, or the ability to organize and process visual materials, improves (Baltes & Schaie, 1974).

Researchers report that fluid intelligence reaches its peak between ages 20 and 30 and declines thereafter (Horn & Donaldson, 1980). **Fluid intelligence** refers to the ability to process information and to make interpretations of events. It differs from crystallized intelligence in being dependent on the functioning and integrity of the nervous system and on one's heredity. It is manifested in speed of thinking, problem-solving ability, and information recall.

Intelligence in Middle Adulthood Various researchers have demonstrated an age-related decline in intellectual functioning (Botwinick, 1977). This is attributed to significant declines in information-processing abilities and other skills involving the central nervous system. People appear to learn new things more slowly as they age. This slowdown begins to be noticeable at middle age and continues for the duration of the life span.

Other research suggests that some aspects of intellectual functioning decline, while others are maintained or improve (Schaie, 1983). Increases continue to occur in crystallized intelligence through the years of middle adulthood. *Crystallized intelligence* involves cognitive skills, such as verbal reasoning and comprehension and spatial relations, which are acquired through educational experiences. *Fluid intelligence* involves information-processing skills, such as those involved in memory, speed of learning, and mathematical calculation. These skills decline through middle adulthood (Knox, 1977).

There are, however, considerable individual differences in the rates at which both of the processes occur—which suggests that more than the aging process is at work here. An individual's "life complexity" appears to affect how quickly these changes in cognitive functioning take place. Such factors as having an intact marriage and engaging in many social interactions can determine the rate of these processes (Schaie, 1983).

Intelligence in Late Adulthood The aged person is often pictured as forgetful, intellectually slow, and indecisive. IQ scores among people of very advanced age (over 80) do show a constant decrease closely associated with the aging process. Scores on the portions of tests that measure problem-solving and speed of performance show a greater decline than scores on the parts that measure verbal skills (Salthouse, 1985). Other information suggests that the lower level of functioning in late adulthood is due more to encountering problems that are new and unfamiliar than to a general diminishment in problem-solving abilities (Labouvie-Vief & Schell, 1982).

A **dual-process model** of intellectual changes has been proposed to explain what happens to mental functioning in late adulthood (Dixon & Baltes, 1986). This model describes two aspects of intelligence: (1) the **mechanics dimension**,

Crystallized intelligence
Skills acquired through education and socialization (e.g. verbal and mathematical skills, inductive reasoning, and interpersonal skills)

Cognitive flexibility
The ability to shift from one thinking style to another

Visuomotor flexibility
The ability to shift from familiar to unfamiliar tasks involving hand-eye coordination

Visualization
The ability to organize and process visual materials

Fluid intelligence
The ability to process information and to make interpretations of events

Dual-process model
Explains what happens to mental functioning in late adulthood through the intelligence aspects of mechanics dimension and pragmatics dimension

Mechanics dimension
Resembles fluid intelligence

which resembles fluid intelligence; and (2) the **pragmatics dimension**, which relates to practical thinking, applying knowledge and skills gained from experience, and wisdom in solving problems of everyday life.

According to this model, elderly people decline in the mechanics dimension because the information that fuels this aspect of intelligence was gained in childhood and has limited usefulness in old age. Pragmatic intelligence, however, is extremely useful at this time of the life span. It can be likened to the wisdom gained from experience. This dimension is much broader in scope than crystallized intelligence. In late adulthood, it enhances the quality of life and may well play an important part in helping elderly individuals achieve the sense of integrity discussed by Erikson (see Chapter 1 for discussion of Erikson's psychosocial theory).

What about crystallized and fluid intelligence in old age? The trends in cognition that began in middle adulthood continue through the years of late adulthood. Crystallized intelligence skills remain stable or even increase during this stage. As you will recall, these are skills acquired through education, such as verbal comprehension. However, fluid intelligence (involved in processing information) declines during this stage.

Pragmatics dimension
Relates to practical thinking, applying knowledge and skills gained from experience, and wisdom in solving problems of everyday life

What is the difference between crystallized and fluid intelligence?

Selection, optimization, and compensation (SOC) theory
Examines how selection, optimization, and compensation assist individuals in coping with the declines associated with aging; often considered a theory of successful aging

Growth
Behaviors meant to increase functioning and adaptation

Maintenance
Behaviors striving to keep functioning at current levels despite declines in processes or ability

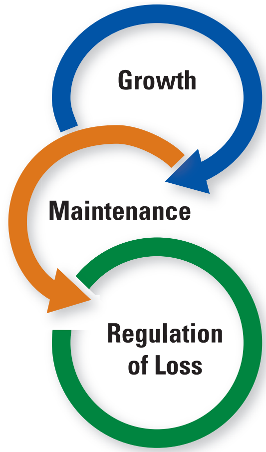
Regulation of loss
Behaviors that allow for reorganization or functioning at lower levels because maintenance is no longer possible

Selection, Optimization, and Compensation

We have learned that during middle adulthood, some aspects of cognitive processes continue to develop, others are maintained, and still others decline. **Selection, optimization, and compensation (SOC) theory** stresses that adaptive aging involves maximizing gains and minimizing losses (Baltes, Lindenberger, & Staudinger, 1998). With aging, resources shift from promoting growth toward maintenance and the regulation of loss (see Figure 9–7). Behaviors associated with selection include goal specification and identifying new goals when faced with loss. Behaviors associated with optimization include focusing attention, persistence, energy, and effort toward goal obtainment. Behaviors associated with compensation include use of external resources and support, learning new skills, and increasing time and effort in the obtainment of goals.

Within SOC theory, **growth** is defined as behaviors meant to increase functioning and adaptation (Baltes, Lindenberger, & Staudinger, 1998). **Maintenance** is defined as behaviors striving to keep functioning at current levels despite declines in processes or ability. **Regulation of loss** is defined as behaviors that allow for reorganization of functioning at lower levels because maintenance is no longer possible.

Figure 9–7 **Selection, Optimization, and Compensation (SOC) Theory Behaviors**



Within SOC theory, describe a behavior or strategy for optimization.

There are four foundational rationales in SOC theory (Baltes, Lindenberger, & Staudinger, 1998). First, biological resources decline in quality and amount as people age. For example, our mitochondria become less functional with aging, increasing the risk for certain illnesses. Second, as age increases the need for culture increases in quality and amount. For example, as one gets older they may need access to better health care more often. Third, as age increases the efficiency of culture decreases. This means that as a person gets older, the effectiveness of cultural interventions decreases. For example, while we can treat many medical conditions associated with old age, we cannot ultimately stop the aging process or prevent death. Fourth, there is a general lack of cultural support structures for the elderly. Said another way, as age increases available cultural resources and support decreases.

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Social support is important throughout life.

Research has focused on how well the SOC theory can be applied to help promote successful aging (Freund & Baltes, 1998). Findings indicate that use of selection, optimization, and compensation strategies and behaviors is associated with satisfaction with age, decreased emotional loneliness, decreased social loneliness, lack of agitation, and positive emotions.

Personality and subjective assessments are related to one's SOC scores (Freund & Baltes, 1998). Individuals high in neuroticism have lower SOC scores. Individuals who are highly invested in their life and rate their subjective health highly have high SOC scores. General intelligence is positively correlated with optimization and compensation, but showed no relationships with selection. Hence, certain personal characteristics may influence one's propensity to employ SOC strategies to optimize aging.

Research using the SOC theoretical framework has found that the focus of goals shifts with age (Freund, 2006). Freund (2006) conducted a study to compare the performance of young adults and older adults in regards to commitment and achievement when performing a sensorimotor task on a computer. The sensorimotor task had two conditions: an optimization condition and a compensation condition. In the optimization condition the stated goal was to perform the task as well as possible. In the compensation condition the stated goal was to prevent losses/decline in the task. Young adults showed greater persistence and motivation in the optimization task, while older adults showed greater persistence and motivation in the compensation task. This study supports the idea that goal focus and motivation shift with aging.

PAUSE *&Process*

- Why do you think children with older siblings achieve a theory of mind sooner than children without older siblings?
- What are the four foundational rationales in SOC theory?

9.1c *Metacognition*

Knowing how to place information into one's memory and how to retrieve that information are new skills for preschoolers. Many researchers believe that children do not master this basic skill until they are older (Galotti, 2017; Siegler & Alibali, 2004; Wellman, 1985). It depends on **metacognition**, or the ability to be aware of, understand, and take note of changes in one's own cognitive processes. Metacognition includes knowing how to pay attention to things to remember them later; what interferes with making one's attention work properly to perform memory storage; and what works well to facilitate the use of one's memory. There is some controversy about whether young children are aware that they can use memory in information-processing. It is clear, however, that in early childhood, improvements occur in acquiring skills that help children control what they learn and remember (Brown, 1982; Siegler & Alibali, 2004).

There is a distinction between metacognition and metamemory. Again, metacognition is the awareness of the extent of one's knowledge. In middle childhood, many individuals improve in metamemory as well as metacognition. **Metamemory** is the awareness of the extent of what is in one's memory. The degree to which children can comprehend their particular capacity of knowledge and memory has important implications for their academic performance (Holt, 1964; National Research Council, 2000).

School-age children who have high levels of metacognition and metamemory may express more misunderstanding about concepts than others. This is because

Metacognition
The ability to be aware of and understand the changes occurring in one's own cognitive processes

Metamemory
An awareness of the extent of one's memory

they are more aware of the extent of their knowledge than children who have lower levels of such awareness. Since they know what information they lack, they understand how to go about getting that information. These children are better students than others. Researchers are discovering ways to help school-age children develop better metacognition and metamemory skills (Cross & Paris, 1988; Galotti, 2017).

Individual ability differences in metacognition become apparent during adolescence (Kuhn & Franklin, 2006). While some adolescents excel in utilizing their metacognitive skills for academic achievement, others falter and fail.

Metacognitive knowledge, or knowing what knowledge you have, increases through early adulthood and into middle adulthood. This knowledge is useful for planning compensation strategies as other aspects of memory wane. There may be some weakening of metacognitive abilities in late adulthood, although more research is needed.

PAUSE *&Process*

- What is metacognition?
- Why may metacognitive abilities be important?

9.1d *Learning and Knowledge*

Early Childhood

Early childhood is a time when children expand their knowledge of the world and develop an attitude of accomplishment. Changes in these years are the foundation for many future learning experiences. This stage is an exciting time when a child learns to explore the environment in many ways.


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Experiences, such as trips to science museums, increase children's learning and knowledge.

Emerging Academic Skills While some children learn foundation for academic skills at daycare or preschool, many others learn such skills from their parents or even older siblings. Early academic skills can also be acquired from educational programming (such as *Sesame Street*, *Between the Lions*, or *Sid the Science Kid*) or computer programs (such as mathisfun.com, ABCmouse.com, or specific software programs). Academic skill development is intertwined with cognitive development and language development (Piper, 2003).

Early Mathematical Skills Culture is very important in determining what mathematical skills are important and need to be learned (Ginsburg, Klein, & Starkey, 1998). Learning the number words and using them to count begins around age 2. For a while, adult (or older child) help is needed to count things with

Metacognitive knowledge
Knowing what knowledge you have

any accuracy. In fact, the average 3-year-old will make a counting mistake 33% of the time. A conceptual understanding of what counting means takes longer than simply memorizing the order of the number words.

Counting with conceptual understanding progresses so that by the age of 4 children have a general conceptual understanding of adding objects or subtracting objects in relation to a group (Ginsburg, Klein, & Starkey, 1998). This does not mean that the average 4-year-old can do addition and subtraction problems. Instead you can show them an original picture with three cows. You can then show them two other pictures: a picture that still has three cows, and a picture with only two cows. If you asked the child, "Which picture shows that one of the cows left?" he or she would be able to choose the picture with only two cows.

Most 3-year-olds do not display a strategy when asked a mathematical question (Ginsburg, Klein, & Starkey, 1998). However, across the preschool years, some rudimentary mathematical strategies emerge. An early strategy to emerge is counting. For example, when asked which of two pictures has more tomatoes, most 4-year-olds will use counting to answer the question. Another early strategy to emerge is learning to start counting from the larger of two addends. For example, consider the following word problem:

> Amy picks four apples from a tree. Then Amy picks three more apples from the tree. How many apples does she have altogether?

A younger child would start counting from one, all the way up to seven. However, an older preschool child would start with the four in mind, and count up three from there. Older preschool children also acquire finger-counting for addition and subtraction problems. Surprisingly, older preschool children have two strategies for division problems: consecutive and overlapping (Ginsburg, Klein, & Starkey, 1998). For example, consider the following word problem:

> Leonardo has five friends. He has 10 pencils that he would like to give to them, making sure that each has the same number of pencils. How many pencils will each friend receive?

This division problem could be solved by a young child using either a consecutive strategy or an overlapping strategy (Ginsburg, Klein, & Starkey, 1998). In the *overlapping strategy*, a child could draw five boxes representing the five friends. He or she would then place a tally mark in each box (representing a pencil) until they counted up to 10. In this way, the child could learn that each friend would receive two pencils. The alternative would be the *consecutive strategy*. With this strategy, the child would distribute the pencils to each friend completely before moving on to the next friend. Early on, this strategy could involve a lot of trial-and-error while trying to figure out how to distribute the total number of pencils equally among the friends.

Early Language Arts Skills To be successful in our society, a child must learn to read and write. However, how do children come to learn that the strange shapes and lines they see on paper stand for letters? Further, how do they come to know that these letters represent specific sounds in their language? Finally, how do they come to know how to share their thoughts, memories, feelings, or imaginations with the written word? All of these skills typically begin in early childhood.

Phonics can be defined as a system "designed to help children use the correspondences between letters and sounds to learn to read and write" (Adams, Treiman, & Pressley, 1998). The first step in phonics is to teach that the letters of the alphabet stand for specific sounds. Some letters have only one sound (e.g., the letter "B"), while other letters have more than one sound (e.g., the letter "G"). Once children know the sounds that letters can make, they can begin sounding out words. Of course, they must learn the language-specific rules during the school-age years (e.g., when "le" is at the end of a two-syllable word, the consonant before the "le" joins it in forming the last syllable, like "candle"). While phonics is very important for reading development, context is also important in helping young readers decode words that are neither familiar, nor easily sounded-out. Additionally, some words must be taught that are neither phonetic nor easily learned through contextual clues. Many of these words, along with high-frequency words, are taught in preschool as "sight words."

Writing skills are limited in early childhood. Writing is both a cognitive and motor skill task. Simply holding the pencil (or crayon) and working the hand to make the desired marks on the paper uses much of the young child's cognitive resources. If a child has to write a story himself, it will be limited and sketchy. However, if a teacher or parent writes a story that the child dictates, the story will be filled with much more information and details.

Middle Childhood

School-age children have many learning experiences, especially in the school system. Individuals are expected to acquire the basic skills our society considers essential for effective functioning during middle childhood. They are also expected to absorb much information about the world of people and things.

Some developmental researchers study the ways that children learn (Bransford, Brown, & Cocking, 2000; Brown et al., 1983). This involves trying to understand how a child's mind perceives and processes information from the external world. These researchers have amended Piagetian and learning theory according to what is known about how computers process and logically handle information.

Academic Skills In the previous section, we learned about some early academic skills acquired during the preschool years. Some mathematical strategies developed in early childhood include counting, use of fingers in counting, counting on from the higher addend, and the use of overlapping and consecutive strategies in division. Some language arts skills in early childhood include the ability to identify letters of the alphabet, beginning phonics, and early writing.

Mathematical Skills You are probably not surprised that some basic academic skills are either acquired or further developed during middle childhood. Mathematics is one such area. School-age children are expected to master the basic operations of addition, subtraction, multiplication, and division. While variations on counting were the predominant strategy for early childhood, more sophisticated skills emerge during middle childhood (Ginsburg, Klein, & Starkey, 1998).

The math taught in school is **codified**. Codified can be defined as math that is written, systematically arranged, and guided by explicit rules (Ginsburg, Klein, & Starkey, 1998). Such math cannot be learned through exploratory learning; instead

Phonics
An approach to teaching reading and spelling based upon phonetics, or the sound of letters

Codified
Math that is written

it must be taught by formal instruction (sometimes called direct instruction). Once again, what mathematical knowledge is taught depends upon the culture.

As we learned in the previous section, counting strategies continue to evolve so that the early school-age child consistently adds on from the larger addend (Ginsburg, Klein, & Starkey, 1998). However, through frequent drills, children eventually store basic number facts into long-term memory (e.g., they will learn that 8 – 5 = 3 without having to do the counting each time). Drills are often useful in learning addition, subtraction, multiplication, and division facts. They can also be useful in learning conversion facts (e.g., converting inches to centimeters). However, a conceptual understanding should be the foundation upon which to drill.

However, much of math is too complicated to be committed to memory via the drill method (Ginsburg, Klein, & Starkey, 1998). For these areas of math algorithms and invented strategies can be useful. An **algorithm** has been "developed and codified over the course of centuries, {and} produces correct results. When used properly, the algorithm always works" (Ginsburg, Klein, & Starkey, 1998, p. 419). For example, $A^2 + B^2 = C^2$ is an algorithm that will always work. Inventive strategies are different, however, from algorithms. **Inventive strategies** make use of one's knowledge and current strategies for help in answering novel problems. For example, a child may know that 5 + 5 = 10. When faced with the problem 5 + 6 = ?, she may choose to add 5 + 5 (which she knows the answer to) and count up 1, instead of counting up five from the number six. Exploiting the base 10 system is a very popular inventive strategy.

American children do poorly in these skills compared to children in other countries (Stigler, Lee, & Stevenson, 1987). Newer instruction methods are based on what we know about how children in the concrete operations stage of cognitive development learn (Resnick, 1989). They stress cognitive processes rather than memorization and calculation skills. By the end of this period, children should understand fractions, decimals, pre-geometry and pre-algebra knowledge, and conversion between the decimal and standard systems of measurement.

Algorithm
A developed procedure to produce correct results in a math problem

Inventive strategies
Making use of one's own knowledge and current strategies in answering a novel problem

Language Arts Skill Reading also shows great development during middle childhood. It involves integration of perceptual, attention, and memory skills. Teachers consider many factors in reading instruction: for example, letter size, readability of text material, and the child's knowledge base (Athey, 1983; National Research Council, 2000). Most children enter the first grade knowing the alphabet; some may already know how to sound out words and read easy books. By the end of this period, children should be able to read most books with ease and fluency. When first learning to read, simply sounding out and identifying the words uses most of working memory. It takes time to be able to read and comprehend what one is reading. Reading instruction is based on teaching different reading skills, use of phonics, and different types of comprehension (Jones, 1986; National Research Council, 2000). Phonics is especially important for reading development. Also, the more a child is read to early in childhood and the more they read independently and with others during middle childhood, the earlier a child is able to read efficiently and for knowledge.

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Reading becomes more efficient during middle childhood.

Finally, writing develops by leaps and bounds during middle childhood. Writing also involves the integration of several cognitive skills. Like reading, it is used in many contexts of classroom learning. Classroom writing is less a communication device than a means of evaluating what children have learned. Early during the school-age years, children will often just list everything they have learned in response to an essay question with little organization or coherence. Across middle childhood, children learn to write with thesis statements, introductions, topic sentences, transitional sentences, summaries, coherence, and organization. Children also learn how to write informational reports, persuasive arguments, research reports, and other such formats during this time. Of course, these skills continue to be improved upon during adolescence and beyond.

? Explain how math and language art skills develop in childhood.

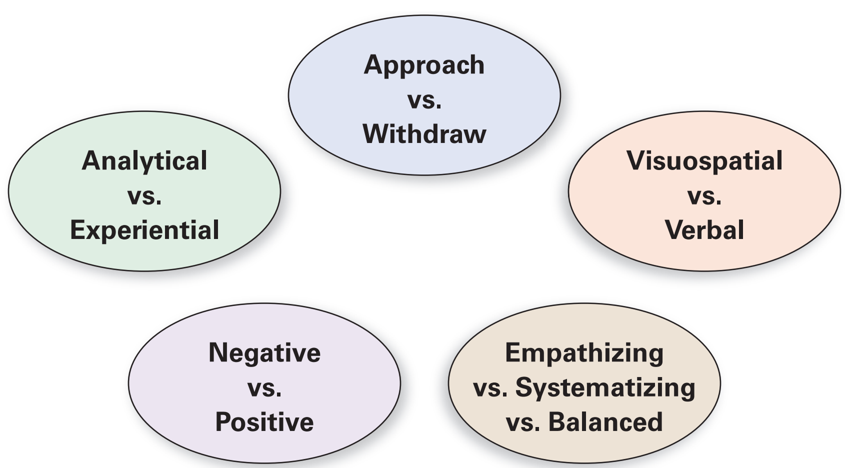
Adolescence and Adulthood

In adolescence and adulthood, an individual may become aware of his or her approach to learning. Additionally, motivation is important for academic achievement. Furthermore, adults may develop expertise in certain areas of knowledge. In this section, we will learn about cognitive styles, motivation, and expert knowledge.

Cognitive Style **Cognitive style** can be defined as "preferred modes of thinking and responding to stimuli" (Goyal, Wice, Kinsbourne, & Castano, 2017, p. 372). Various types of cognitive style have been posited and researched (see Figure 9–8).

Cognitive style
Preferred modes of thinking and responding to stimuli

Figure 9–8 Types of Cognitive Style



While we will not discuss all of the cognitive styles in Figure 9–8, we will highlight a few that have been the subject of recent research. Empathizing-systemizing (E-S) theory proposes three cognitive styles: empathizing, systemizing, and balanced (Wakabayashi, Sasaki, & Ogawa, 2012). The **empathizing cognitive style** is defined as "the drive to understand and appropriately respond to the mental states of others" (p. 25). The **systemizing cognitive style** is defined as "the drive to analyze or construct any kind of system that follows rules" (p. 25). The **balanced cognitive style** uses the empathizing and systemizing cognitive styles equally. Research has found that females tend to utilize the empathizing cognitive style more than males, while males tend to utilize the systemizing cognitive style more than females.

Another cognitive style is referred to as the negative cognitive style. A **negative cognitive style** is defined as people who make "stable, global attributions, infer negative self-characteristics, and anticipate negative consequences when negative events occur" (Nusslock et al., 2011, p. 497). A recent study with adolescents found that those with a negative cognitive style are more likely to develop a sense of hopelessness when facing stressful or difficult situations (Mac Giollabhui et al., 2018). In turn, this sense of hopelessness develops at the onset of major depression. Hence, having a negative cognitive style can lead to mental health troubles. However, cognitive styles are not set in stone.

Cognitive style may change during middle adulthood (Knox, 1977; Labouvie-Vief, 1985, 1986). The style of thinking that emerges during early adulthood emphasizes exploration of options in solving problems. According to Riegel (1973, 1975), mature thinking involves a tolerance of contradictions and conflicts out of the realization that this is how the world functions. This ability is referred to as "**aintegration** (not integrated, maintaining incongruence), defined as the human ability to bear cognitive/emotional complexity, manifested in the capability to maintain incongruence and live with inconsistencies, discontinuities, contradictions and paradox, and yet not experience strain or discomfort" (Lomranz & Benyamini, 2016, p. 79). In middle adulthood, people rely more on subjectivity and intuition in contrast to the strict logical processing that characterizes earlier adult cognitive style. Middle-aged people incorporate lessons learned from past mistakes into their problem-solving strategies. The ability is especially valuable in ambiguous situations.

Motivation and Learning Motivation is very important for learning in college, as throughout childhood. Motivation is important because it "affects the amount of time that people are willing to devote to learning" (National Research Council, 2000). An environment that promotes motivation for learning provides challenges that incorporate the following:

- Material and assignments that are appropriate for the level of knowledge and skills of the learner
- Social opportunities in which an individual can contribute knowledge
- Opportunities for learners to see the usefulness and applicability of the material they are being asked to learn

Some motivation is intrinsic, while other motivation is extrinsic (for example, see Boggiano & Pittman, 1992; Deci, Koestner, & Ryan, 2001; Eccles & Wigfield, 2002). **Intrinsic motivation** is internally generated—a person is driven to learn

Empathizing cognitive style
The drive to comprehend accurately and respond to the thoughts, feelings, and actions of others

Systemizing cognitive style
The drive to understand or construct systems that follow rules

Balanced cognitive style
The use of empathizing and systemizing to maintain cognitive equilibrium and stability

Negative cognitive style
People who make stable, global attributions, infer negative self-characteristics, and anticipate negative consequences when negative events occur

Aintegration
The human ability to bear cognitive/emotional complexity, manifested in the capability to maintain incongruence and live with inconsistencies, discontinuities, contradictions and paradox, and yet not experience strain or discomfort

Intrinsic motivation
A person's internally generated drive to learn because it is inherently enjoyable

because learning is inherently enjoyable to him or her. **Extrinsic motivation** is externally generated—a person is driven to learn because of what he or she will receive in doing so (e.g., good grades, stickers, money, avoidance of punishment, etc.). In general, researchers stress the superiority of intrinsic motivation for academic achievement.

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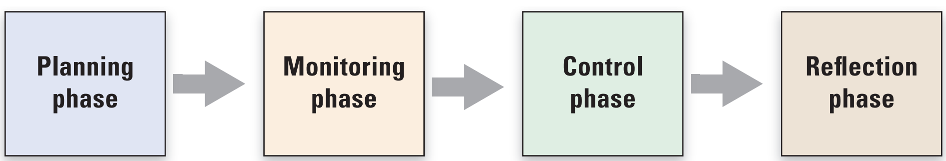
Intrinsic motivation is necessary for academic success.

Beyond motivation, the ability to regulate what one is learning is also important for academic achievement and life-long learning (Pintrich & Zusho, 2001). **Self-regulated learning** can be defined as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior in the service of those goals, guided and constrained by both personal characteristics and the contextual features of the environment (Pintrich & Zusho, 2002, p. 250). Working memory, prior content knowledge, and metacognitive abilities are all important for self-regulation. Theories on self-regulated learning differ in their specifics, but most acknowledge four general areas or phases important to this process: planning, monitoring, control, and reflection (as illustrated in Figure 9–9).

Figure 9–9 **Four Phases Important for Self-Regulation**



During the **planning phase**, a person sets goals and considers what they already know and what they need to still learn (Pintrich & Zusho, 2001). This is a time of effortful planning, keeping in mind goals, knowledge, and context. The **monitoring phase** involves an individual maintaining awareness of what they are learning and thinking. A person is mindful of time management and decides what help may be needed. During the **control phase**, a person decides if changes need to be made in their approach to the learning task and makes necessary adaptations. This can be a phase where a person decides to seek help, renegotiate the task, or give up. A person may also come to realize that they need to increase effort. Finally, the **reflection phase** is a time to judge one's own work, make attributions in regards to the quality of the work, and evaluate the outcomes within the given context.

Expert Versus Novice Knowledge During middle adulthood, many individuals develop expertise within their area of work or hobby. **Expertise** can be defined as having extensive experience, knowledge, and understanding within a specific area of interest (National Research Council, 2000). A **novice** would be someone with limited experience, knowledge, or understanding within a specific area of interest. Experts and novices in a given realm differ in their abilities to problem-solve, remember, and reason in this domain.

Extrinsic motivation
A person's drive to learn because of what he or she will receive in doing so

Self-regulated learning
When a person keeps track of what they have learned, what they still need to learn, and have a strategy for how to learn it

Planning phase
A person sets goals and considers what they already know and what they need to still learn

Monitoring phase
Maintaining awareness of what is being learned and thought

Control phase
The period where necessary changes and/or adaptations are made in the approach to the learning task

Reflection phase
The time to judge one's own work, make attributions in regards to the quality of the work, and evaluate the outcomes within the given context

Expertise
Having extensive experience, knowledge, and understanding within a specific area of interest

Novice
A person with limited experience, knowledge, or understanding within a specific area of interest

Experts differ from novices in their *ability to detect meaningful patterns of information* (National Research Council, 2000). The detection of these meaningful patterns activates knowledge of corresponding problem-solving strategies and the implications of these strategies. Experts are also better able to "chunk" or group individual pieces of information into meaningful units and fit this information into a vast network of knowledge. From doctors to chess players, this ability to detect meaningful patterns of information allows experts to outperform novices consistently.

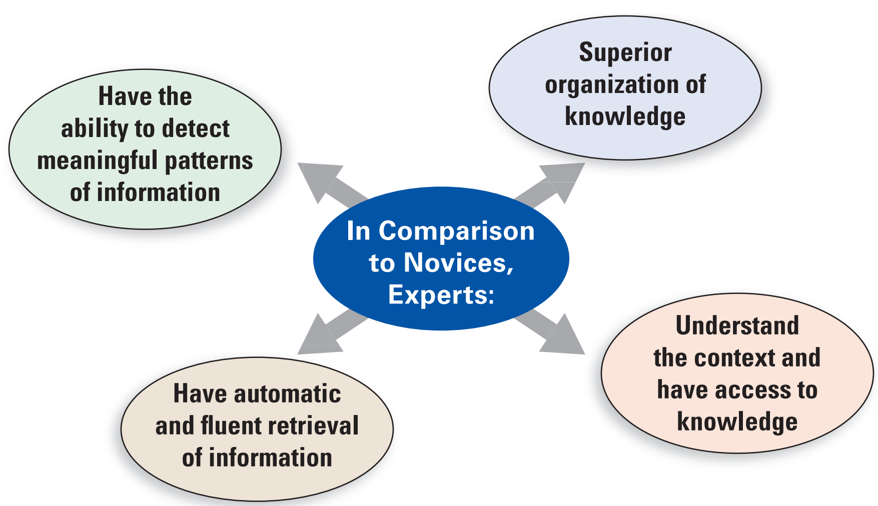
The *organization of knowledge* is another area that experts differ from novices (National Research Council, 2000). It's not just that experts know more, it is that they structure and store the information in a better organizational framework. While novices typically approach learning new information as a series of facts and information, experts organize specific facts within a web that is organized around major orienting (or core) concepts. Hence, when a new fact or information is learned, experts can easily link this new information into the greater web of knowledge. "Within this picture of expertise, 'knowing more' means having more conceptual chunks in memory, more relations or features defining each chunk, more interrelations among the chunks, and efficient methods for retrieving related chunks and procedures for applying these informational units in problem-solving contexts" (National Research Council, 2000, p. 38).

Context and access to knowledge is another realm in which experts differ from novices (National Research Council, 2000). For any given problem, only a small part of an expert's knowledge is applicable. For example, an oncologist has an immense amount of knowledge about cancer. However, for any given patient only a comparatively small amount of this knowledge is utilized. Hence, experts not only have more knowledge, but they are skilled in accessing the specific information that they need for any given problem. This aspect of expert knowledge and retrieval is referred to as **conditionalized knowledge**.

Conditionalized knowledge
The skill experts have in retrieving the specific information that they need for any given problem

Novices sometimes struggle to retrieve information from memory that is needed to solve a problem. Experts have achieved *automatic and fluent retrieval* of information from memory (National Research Council, 2000). So not only are they better at retrieving relevant information, they can retrieve this information with great speed and little effort.

Figure 9–10 Knowledge: Experts Versus Novices



We have just gone over some of the general differences in cognitive processes between novices and experts. Interestingly, there are at least two very different types of experts (National Research Council, 2000). **Merely skilled experts** have expertise that functions largely on routine. **Highly competent experts** exhibit great adaptability, flexibility, and creativity in utilizing their expertise across a variety of situations. Merely skilled experts display extensive skills when solving problems and focus on using these skills as quickly and efficiently as possible. Highly competent experts capitalize on solving problems as an opportunity to be creative in their strategies and develop new skills. Highly competent experts are sometimes said to possess **adaptive expertise**, which is an approach to problems that is characterized by flexibility and promotes lifelong learning. Both types of experts monitor their understanding and problem-solving approach and make adjustments as needed.

Merely skilled experts
Expertise that functions largely on routine

Highly competent experts
Experts who exhibit great adaptability, flexibility, and creativity in utilizing their expertise across a variety of situations

Adaptive expertise
An approach to problems that is characterized by flexibility and promotes lifelong learning

PAUSE &Process

- Describe how academic skills develop.
- Explain the differences between novices and experts.

Summary

1. Infants are born with some basic processes that allow for learning and information-processing. Many of these processes are evident prenatally, but we can test them more definitively after birth. Infants are capable of forming memories, association, recognition, imitation, and recall. These early basic processes pave the way for future problem-solving, memory strategies, and other information-processing development.
2. Information-processing skills increase during early childhood. Memory strategies improve and early academic skills emerge. The degree to which children have metacognitive skills in early childhood is still open to debate.
3. School-age children process information in ways that facilitate the learning experiences required by school systems. They demonstrated their improved abilities to process information in their use of attention and use of memory. School-age children become better at selective attention in gathering information from the environment. Their memory improves significantly and they are better able to recall information when performing cognitive tasks. School-age children use various methods and strategies for memory storage. Many different scripts are formed during this stage to facilitate routines. Other scripts are based on understanding social roles. School-age children show great improvements in metacognition and metamemory. Those who have higher levels of these kinds of awareness perform better in school.
4. Attention, memory, and metacognitive skills are either still developing further or are maintained throughout adolescence, early adulthood, and into middle adulthood. Two principle cognitive changes occur in late adulthood: A decline in general processing speed and significant declines in some areas of memory. Attention shows declines in some areas.
5. Selection, optimization, and compensation theory strives to assist individuals in aging optimally by teaching strategies that minimize losses and maximize gains. By modifying goal selection, optimizing current functioning levels, and compensating with external support when needed, adults can continue to live happily throughout life.
6. Experts and novices differ in their cognitive abilities. In comparison to novices, experts have a broader knowledge base, organize their knowledge better, and have better retrieval of knowledge. There are two main types of experts with varying degrees of adaptive expertise.
7. Cognitive style is adapted to involve past experiences and intuition in making decisions.

Self-Quiz

1. What is meant by attention?
2. How is attention understood during early and middle childhood?
3. Explain changes in attention during middle adulthood.
4. How do the posterior attention system and the anterior attention system differ in their attentional processes?
5. Describe parallel processing in late adulthood.
6. What are three theories about why we have infantile amnesia?
7. What two memory strategies are prevalent during early childhood?
8. Explain the three phases of memory discussed in this chapter.
9. Define metacognition and explain how it is impacted by development.
10. List the aspects of memory that show declines in later adulthood and the aspects of memory that remain relatively intact.
11. Within SOC theory, describe a behavior or strategy for selection.
12. Within SOC theory, describe a behavior or strategy for optimization.
13. Within SOC theory, describe a behavior or strategy for compensation.
14. Provide an example of a cognitive process that shows growth, maintenance, and regulation of loss throughout the life span.
15. Explain and provide a unique example for each of the four foundational rationales in SOC theory.
16. Explain how math and language art skills develop in childhood.
17. How could the ability to detect meaningful patterns of information assist an expert teacher?
18. In what area or activity would you consider yourself an expert (or on your way to becoming an expert)?
19. Which type of surgeon would you want to operate on you: a merely skilled expert or a highly competent expert? Provide reasons for your choice.
20. What is meant by math being codified?
21. What are some math strategies in middle childhood?

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