Cognition

CHAPTER 7

KEY TERMS

Memory
Three-box/information-processing model
Levels of processing model
Sensory memory
George Sperling
Iconic memory
Selective attention
Echoic memory
Short-term memory (working memory)
Chunking
Mnemonic devices
Rehearsal
Long-term memory
Episodic memory
Semantic memory
Procedural memory
Explicit memories (also called declarative memories)
Implicit memories (also called nondeclarative memories)
Eidetic, or photographic, memory
Retrieval
Recognition
Recall
Primacy effect
Recency effect
Serial position effect (also called serial position curve)
Tip-of-the-tongue phenomenon
Semantic network theory
Flashbulb memories
State-dependent memory
Mood congruent memory
Constructed (or reconstructed) memory
Relearning effect
Retroactive interference
Proactive interference
Anterograde amnesia
Retrograde amnesia
Long-term potentiation
Phonemes
Morphemes
Syntax
Language acquisition
Overgeneralization or overregularization
Language acquisition device
Linguistic relativity hypothesis
Prototypes
Images
Algorithm
Heuristic
Representativeness heuristic
Belief bias or belief perseverance
Functional fixedness
Confirmation bias
Convergent thinking
Divergent thinking
Availability heuristic

OVERVIEW OF MEMORY

The central question of memory research is: What causes us to remember what we remember and to forget what we forget? Memory is defined by researchers as any indication that learning has persisted over time. You might remember the bully who pushed you into the mud in second grade but forget your appointment with the school counselor. What are the processes that determine which events stick in

our memories? Why and how do we lose information from memory? How accurate are our memories? Researchers do not have the final answers to any of these questions. However, models and principles of memory have emerged from the research that give us insight into how we remember.

MODELS OF MEMORY

Several different models, or explanations, of how memory works have emerged from memory research. We will review two of the most important models: the three-box/information-processing model and the levels of processing model. Neither model is perfect. They describe how memory works in different ways and can describe some memory experiences better than others.

Three-Box/Information-Processing Model

HINT

Do not take this memory model too literally. The model describes the process, not physical structures. There is not one spot in the brain that is the long-term memory spot. Memories are distributed around the cortex. Researchers use the model to describe the process rather than define how and where the brain stores memories physically.

The principle model of memory is the three-box model, also called the information-processing model. This model proposes the three stages that information passes through before it is stored (see Fig. 7.1).

External events are first processed by our sensory memory. Then some information is encoded into our short-term (or working) memory. Some of that information is then encoded into long-term memory.

SENSORY MEMORY

The first stop for external events is *sensory memory*. It is a split-second holding tank for incoming sensory information. All the information your senses are processing right now is held in sensory memory for a very short period of time (less than a second). Researcher George Sperling demonstrated this in a series of experiments in which he flashed a grid of nine letters, three rows and three columns,

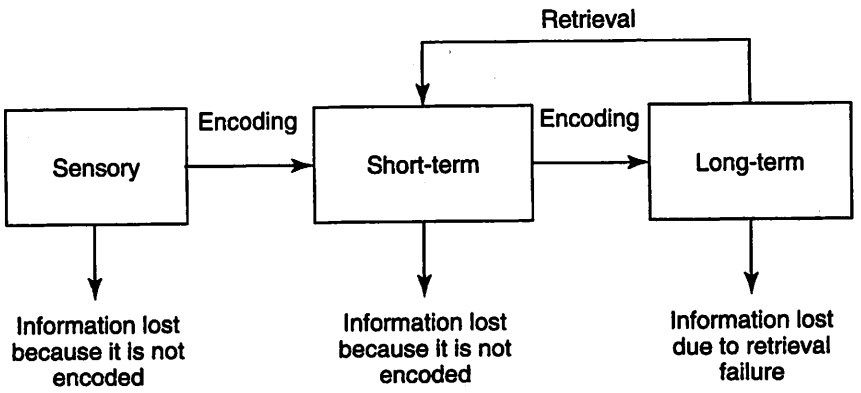

Figure 7.1. Atkinson and Shiffring three-box/information-processing model.

to participants for 1/20th of a second. The participants in the study were directed to recall either the top, middle, or bottom row immediately after the grid was flashed at them. (Sperling used a high, medium, or low tone to indicate which row they should recall.) The participants could recall any of the three rows perfectly. This experiment demonstrated that the entire grid must be held in sensory memory for a split second. This type of sensory memory is called *iconic memory*, a split-second perfect photograph of a scene. Other experiments demonstrate the existence of *echoic memory*, an equally perfect brief (3–4 second) memory for sounds.

Most of the information in sensory memory is not encoded, however. Only some of it is encoded, or stored, in *short-term memory*. Events are encoded as visual codes (a visual image), acoustic codes (a series of sounds), or semantic codes (a sense of the meaning of the event). What determines which sensory messages get encoded? *Selective attention*. We encode what we are attending to or what is important to us. Try the following experiment. Pay attention to how your feet feel in your socks right now. You feel this now because the sensory messages from your feet are encoded from sensory memory into short-term memory. Why did you not feel your feet before? Because the messages entered sensory memory but were not encoded because you were not selectively attending to them. Sometimes selective attention is not as controlled. You have probably had the experience of speaking with one person at a party but then hearing someone say your name across the room. You were selectively attending to the person you were talking to. However, once a sensory message entered sensory memory that you knew was important (like your name or hearing someone shout "Fire!"), you switched your attention to that message, and it was encoded into your short-term memory. (This is also called the *cocktail party* effect, see Chapter 4 for more information about this phenomenon.)

SHORT-TERM/WORKING MEMORY

Short-term memory is also called working memory because these are memories we are currently working with and are aware of in our consciousness. Everything you are thinking at the current moment is held in your short-term or working memory. Short-term memories are also temporary. If we do nothing with them, they usually fade in 10 to 30 seconds. Our capacity in short-term memory is limited on average to around seven items, but this limit can be expanded through a process called *chunking*. If you want to remember a grocery list with 15 items on it, you should chunk, or group, the items into no more than seven groups. Most *mnemonic devices*, memory aids, are really examples of chunking. If you memorized the names of the planets by remembering the sentence "My very excellent mother just served us nine pizzas," you chunked the names of the planets into the first letters of the words in one sentence.

Another way to retain information in short-term memory is to *rehearse* (or repeat) it. When you look up a phone number and repeat it to yourself on the way to the phone, you are rehearsing that information. Simple repetition can hold information in short-term memory, but other strategies are more effective in ensuring short-term memories are encoded into long-term memory.

LONG-TERM MEMORY

Since memories fade from sensory and short-term memory so quickly, we obviously need a more permanent way to remember events. Long-term memory is our permanent storage. As far as we know, the capacity of long-term memory is unlimited. No one reports their memory as being full and unable to encode new information. Studies show that once information reaches long-term memory, we will likely remember it for the rest of our lives. However, memories can decay or fade from long-term memory, so it is not truly permanent (see the section on forgetting). Long-term memories can be stored in three different formats:

Episodic memory	Memories of specific events, stored in a sequential series of events. Example: remembering the last time you went on a date.
Semantic memory	General knowledge of the world, stored as facts, meanings, or categories rather than sequentially. Example: What is the difference between the terms *effect* and *affect*?
Procedural memory	Memories of skills and how to perform them. These memories are sequential but might be very complicated to describe in words. Example: How to throw a curveball.

Memories can also be implicit or explicit. *Explicit memories* (also called declarative memories) are what we usually think of first. They are the conscious memories of facts or events we actively tried to remember. When you study this chapter, you try to form explicit memories about the memory theories. *Implicit memories* (also called nondeclarative memories) are unintentional memories that we might not even realize we have. For example, while you are helping your friend clean her house, you might find that you have implicit memories about how to scrub a floor properly after watching your parents do it for so many years.

Memory researchers are particularly interested in individuals who demonstrate *eidetic*, or *photographic, memory*. Psychologist Alexandra Luria studied a patient with eidetic memory who could repeat a list of 70 letters or digits. The patient could even repeat the list backward or recall it up to 15 years later! Luria and other researchers showed that these rare individuals seem to use very powerful and enduring visual images.

HINT:

Some people say they have a photographic memory when what they mean is very good memory. True eidetic memory occurs very rarely. Most of us could enhance our memories through training with mnemonic devices, context, and visual imagery.

Levels of Processing Model

An alternate way to think about memory is the levels of processing model. This theory explains why we remember what we do by examining how deeply the memory was processed or thought about. Memories are neither short- nor long-term. They are *deeply* (or *elaboratively*) *processed* or *shallowly* (or *maintenance*) *pro-*

cessed. If you simply repeat a fact to yourself several times and then write it on your test as quickly as you can, you have only shallowly processed that fact and you will forget it quickly. However, if you study the context and research the reasons behind the fact, you have deeply processed it and will likely recall it later. According to the levels of processing theory, we remember things we spend more cognitive time and energy processing. This theory explains why we remember stories better than a simple recitation of events and why, in general, we remember questions better than statements. When we get caught up in a story or an intriguing question, we process it deeply and are therefore more likely to remember it.

RETRIEVAL

The last step in any memory model is retrieval, or getting information out of memory so we can use it. There are two different kinds of retrieval: recognition and recall. *Recognition* is the process of matching a current event or fact with one already in memory (for example, "Have I smelled this smell before?"). *Recall* is retrieving a memory with an external cue (for example, "What does my Aunt Beki's perfume smell like?"). Studies have identified several factors that influence why we can retrieve some memories and why we forget others.

One factor is the order in which the information is presented. Many studies demonstrate the primacy and recency effects. The *primacy effect* predicts that we are more likely to recall items presented at the beginning of a list. The *recency effect* is demonstrated by our ability to recall the items at the end of a list. Items in the middle are most often forgotten. Together the primacy and recency effect demonstrate the *serial position effect* (also called *serial position curve*). This effect is seen when recall of a list is affected by the order of items in a list.

Context is an important factor in retrieval. Have you ever tried to remember someone's name and start listing things about their appearance or personality until you finally come up with the name? This temporary inability to remember information is sometimes called the *tip-of-the-tongue-phenomenon.* One theory that explains why this might work is the *semantic network theory.* This theory states that our brain might form new memories by connecting their meaning and context with meanings already in memory. Thus, our brain creates a web of interconnected memories, each one in context tied to hundreds or thousands of other memories. So, by listing traits, you gradually get closer and closer to the name and you are finally able to retrieve it. Context also explains another powerful memory experience we all have. If you ask your parents where they were when Kennedy was shot or the shuttle Challenger exploded, they are likely to give you a detailed description of exactly what they were doing at that time. These *flashbulb memories* are powerful because the importance of the event caused us to encode the context surrounding the event. However, some studies show that flashbulb memories can be inaccurate. Perhaps we tend to construct parts of the memory to fill in gaps in our stories (see "Constructive Memory," page 156).

The emotional or situational context of a memory can affect retrieval in yet another way. Studies consistently demonstrate the power of *mood-congruent memory* or the greater likelihood of recalling an item when our mood matched the mood we were in when the event happened. We are likely to recall happy events when

we are happy and recall negative events when we are feeling pessimistic. *State-dependent memory* refers to the phenomenon of recalling events encoded while in particular states of consciousness. If you suddenly remember an appointment while you are drowsy and about to go to sleep, you need to write it down. Very possibly, you will not remember it again until you are drowsy and in the same state of consciousness. Alcohol and other drugs affect memory in similar ways.

CONSTRUCTIVE MEMORY

Maybe you have seen media coverage of the "*recovered memory*" phenomenon. Individuals claim suddenly to remember events they have "repressed" for years, often in the process of therapy. Parents have been accused of molesting and even killing children based on these recovered memories. While some of the memories can be corroborated by other means, memory researchers like Elizabeth Loftus have shown that many of these memories may be constructed or false recollections of events. A *constructed* (or reconstructed) *memory* can report false details of a real event or might even be a recollection of an event that never occurred. Studies show that leading questions can easily influence us to recall false details, and questioners can create an entirely new memory by repeatedly asking insistent questions. Constructed memories feel like accurate memories to the person recalling them. The only way to differentiate between a false and a real memory is through other types of evidence, such as physical evidence or other validated reports of the event. While some genuine memories may be recalled after being forgotten for years, researchers and therapists are investigating ways to ensure memories are accurate and innocent people are not accused of acts they did not commit.

FORGETTING

Sometimes, despite our best efforts, we forget important events or facts that we try and want to remember. One cause of forgetting is decay, forgetting because we do not use a memory or connections to a memory for a long period of time. For example, you might memorize the state capitals for a civics test but forget many of them soon after the test because you do not need to recall them. However, your studying was not in vain! Even memories that decay do not seem to disappear completely. Many studies show an important *relearning* effect. If you have to memorize the capitals again, it will take you less time than it did the first time you studied them.

Another factor that causes forgetting is *interference*. Sometimes other information in your memory competes with what you are trying to recall. Interference can occur through two processes:

Retroactive interference	Learning new information interferes with the recall of older information. If you study your psychology at 3:00 and your sociology at 6:00, you might have trouble recalling the psychology information on a test the next day.

Proactive interference

Older information learned previously interferes with the recall of information learned more recently. If a researcher reads you a list of items in a certain order, then rereads them differently and asks you to list them in the new order, the old list proactively interferes with recall of the new list.

HINT

Some students find remembering the difference between retroactive and proactive interference difficult. Focus on which type of information is trying to be recalled. If old information is what you are searching for, retroactive (older) interference most likely applies. If you are searching for newer information, proactive (new) interference might take place.

HOW MEMORIES ARE PHYSICALLY STORED IN THE BRAIN

Researchers know some of the brain processes and structures involved in memory, but much of this process is still a mystery. By studying patients with specific brain damage, we know that the hippocampus is important in encoding new memories. However, other brain structures are involved. Individuals with damage to the hippocampus might have *anterograde amnesia* (they cannot encode new memories), but they can recall events already in memory. They can learn new skills, although they will not remember learning them. This indicates that the memory for these skills, or procedural memory, is stored elsewhere in the brain (studies on animals indicate procedural memories are stored in the cerebellum).

At the neurological level, researchers focus on a process called *long-term potentiation*. Studies show that neurons can strengthen connections between each other. Through repeated firings, the connection is strengthened and the receiving neuron becomes more sensitive to the messages from the sending neuron. This strengthened connection might be related to the connections we make in our long-term memory.

LANGUAGE

For us to conceive of thought without language is impossible. Your brain is processing the language you are reading right now. If you stop to think about the previous sentence, you think about it using language. Language is intimately connected to cognition. Some psychologists investigate how language works and how we acquire it in an attempt to understand better how we think and behave.

Elements of Language

All languages can be described with *phonemes* and *morphemes*. Phonemes are the smallest units of sound used in a language. English speakers use approximately 44 phonemes. If you have studied another language or if your primary language is not English, you have experience with other phonemes. Native Spanish speakers find the rolled *R* phoneme natural, but many English speakers have difficulty learning

how to produce it since it is not used in English. Speakers of other languages have difficulty learning some English phonemes.

A morpheme is the smallest unit of meaningful sound. Morphemes can be words, such as *a* and *but*, or they can be parts of words, such as the prefixes *an-* and *pre-*. So language consists of phonemes put together to become morphemes, which make up words. These words are then spoken or written in a particular order, called *syntax*. Each language has its own syntax, such as where the verb is usually placed in the sentence. By examining phonemes, morphemes, and syntax (the grammar of a language), psychologists can describe different languages in detail.

Language Acquisition

Many psychologists are particularly interested in how we learn language. Often, developmental psychologists are curious about how our language learning reflects or predicts our cognitive development. These studies show that while babies are learning very different languages, they progress through the same basic stages in order to master the language. First, if you have ever been around babies, you know that babies babble. This is often cute, and it is the first stage of *language acquisition* that occurs about 4 months of age. The babbling stage appears to be innate; even babies born completely deaf go through the babbling stage. A baby's babble represents experimentation with phonemes. They are learning what sounds they are capable of producing. Babies in this stage are capable of producing any phoneme from any language in the world. So while you may not be able to roll your *R*s, your infant sister can! As language acquisition progresses, we retain the ability to produce phonemes from our primary language (or languages) and lose the ability to make some other phonemes. This is one reason why learning more than one language starting at infancy may be advantageous. Babbling progresses into utterances of words as babies imitate the words they hear caregivers speaking. The time during which babies speak in single words (holophrases) is sometimes called the *holophrastic stage* or *one-word stage*. This usually happens around their first birthday.

The next language acquisition stage occurs at around 18 months and is called *telegraphic speech* or *two-word stage*. Toddlers will combine the words they can say into simple commands. Meaning is usually clear at this stage, but syntax is absent. When your little brother shouts, "No book, movie!" you know that he means, "I do not wish to read a book at this time. I would prefer to watch a movie." Children begin to learn grammar and syntax rules during this stage, sometimes misapplying the rules. For example, they might learn that adding the suffix *-ed* signifies past tense, but they might apply it at inappropriate times, such as, "Marky hitted my head so I throwed the truck at him." Children gradually increase their abilities to combine words in proper syntax if these uses are modeled for them. This misapplication of grammar rules is called *overgeneralization* or *overregularization*.

One important controversy in language acquisition concerns how we acquire language. Behaviorists theorized that language is learned like other learned behaviors: through operant conditioning and shaping. They thought that when children used language correctly, they got rewarded by their parents with a smile or other encouragement, and therefore they would be more likely to use language correctly in the future. More recently, cognitive psychologists challenged this theory. They

point out the amazing number of words and language rules learned by children without explicit instruction by parents. Researcher Noam Chomsky theorized that humans are born with a *language acquisition device*, the ability to learn a language rapidly as children (this is also called the *nativist theory of language acquisition*). Chomsky pointed to the retarded development of language in cases of children deprived of exposure to language during childhood. He theorized that a critical period (a window of opportunity during which we must learn a skill, or our development will permanently suffer) for learning language may exist. Most psychologists now agree that we acquire language through some combination of conditioning and an inborn propensity to learn language.

Language and Cognition

If language is central to the way we think, how does it influence what we are able to think about? Psychologist Benjamin Whorf theorized that the language we use might control, and in some ways limit, our thinking. This theory is called the *linguistic relativity hypothesis*. Many studies demonstrate the effect of labeling on how we think about people, objects, or ideas, but few studies show that the language we speak drastically changes what we can think about.

THINKING AND CREATIVITY

Describing Thought

Trying to describe thought is problematic. Descriptions are thoughts, so we are attempting to describe thought using thought itself. A global, all-inclusive definition of thought is difficult, but psychologists try to define types or categories of thoughts. *Concepts* are similar to the schemata mentioned previously. We each have cognitive rules we apply to stimuli from our environment that allow us to categorize and think about the objects, people, and ideas we encounter. These rules are concepts. Our concept of mom is different from our concept of dad, which is different from our concept of a soccer game. We may base our concepts on *prototypes* or what we think is the most typical example of a particular concept.

Another type of thought, *images*, are the mental pictures we create in our minds of the outside world. Images can be visual, such as imagining what your cat looks like. However, images can also be auditory, tactile, olfactory, or an image of a taste, such as thinking about what hot chocolate tastes like on a very cold day.

Problem Solving

Many researchers try to study thought by examining the results of thinking. Researchers can ask participants to solve problems and then investigate how the solutions were reached. This research indicates at least two different problem-solving methods we commonly use and some traps to avoid when solving a problem.

ALGORITHMS

One way to solve a problem is to try every possible solution. An *algorithm* is a rule that guarantees the right solution by using a formula or other foolproof method.

If you are trying to guess a computer password and you know it is a combination of only two letters, you could use an algorithm and guess pairs of letters in combination until you hit the right one. What if the password is a combination of five letters, not two? Sometimes algorithms are impractical, so a shortcut is needed to solve certain problems.

HEURISTICS

A *heuristic* is a rule of thumb—a rule that is generally, but not always, true that we can use to make a judgment in a situation. For example, if you are trying to guess the password mentioned previously, you might begin by guessing actual five-letter words rather than random combinations of letters. The password might be a meaningless combination of letters, but you know that passwords are most often actual words. This heuristic limits the possible combinations dramatically. The following shows two specific examples of heuristics.

Availability heuristic	Judging a situation based on examples of similar situations that come to mind initially. This heuristic might lead to incorrect conclusions due to variability in personal experience. For example, a person may judge his or her neighborhood to be more dangerous than others in the city simply because that person is more familiar with violence in his or her neighborhood than in other neighborhoods.
Representativeness heuristic	Judging a situation based on how similar the aspects are to prototypes the person holds in his or her mind. For example, a person might judge a young person more likely to commit suicide because of a prototype of the depressed adolescent when, in fact, suicide rates are not higher in younger populations.

Use of these heuristics is typically helpful but can lead to specific problems in judgments. Overconfidence is our tendency to overestimate how accurate our judgments are. How confident we are in a judgment is not a good indicator of whether or not we are right. In studies, most people will report extreme confidence in a judgment that turns out to be wrong in a significant number of cases. Two concepts closely related to overconfidence are *belief bias* and *belief perseverance*. Both of these concepts concern our tendency not to change our beliefs in the face of contradictory evidence. Belief bias occurs when we make illogical conclusions in order to confirm our preexisting beliefs. Belief perseverance refers to our tendency to maintain a belief even after the evidence we used to form the belief is contradicted. Overall, these concepts demonstrate that humans are generally more confident in our beliefs than we should be, and we often stick with our beliefs even when presented with evidence that disproves them.

IMPEDIMENTS TO PROBLEM SOLVING

Problem-solving research identifies some common mistakes people make while trying to solve problems. *Rigidity* (also called *mental set*) refers to the tendency to fall into established thought patterns. Most people will use solutions or past experience to try to solve novel problems. Occasionally, this tendency prevents them from seeing a novel solution. One specific example of rigidity is *functional fixedness*, the inability to see a new use for an object. One of my students recently got his car stuck up to the axles in mud. Our attempts to pull him out failed until another student pointed out we could use the car jack to raise the car and put planks under the tires. Most of us thought of the jack only as a tool to help with a flat tire, not getting a car out of the mud. Another common trap in problem solving is not breaking the problem into parts. Studies show that good problem solvers identify subgoals, smaller and more manageable problems they need to solve in order to solve the whole problem. Tackling the problem in these smaller parts help good problem solvers be more successful.

Another obstacle to successful problem solving is *confirmation bias*. Many studies show that we tend to look for evidence that confirms our beliefs and ignore evidence that contradicts what we think is true. As a consequence, we may miss evidence important to finding the correct solution. For example, when I prepare my students for the AP test, I may emphasize studying techniques or information that I am familiar with and think are very important. What I think is important may be very different than what the designers of the test emphasize. My confirmation bias could hinder the students' success on the test.

Even the way a problem is presented can get in the way of solving it. *Framing* refers to the way a problem is presented. Presentation can drastically change the way we view a problem or an issue. If I tell my students, "The majority of my students have been able to solve this logic problem," they would most likely feel confident and not expect much of a challenge. However, if I tell them, "Almost half of the students in my classes never get the answer to this logic puzzle," they would most likely expect a very difficult task. In both cases I am really telling them that 51 percent of the students can solve the logic problem, but the way I frame the task changes their expectation and possibly their ability to solve the problem. Researchers must be careful about unintentionally framing questions in ways that might influence participants in their studies.

Creativity

If you thought defining thought was tough, try defining creativity! The concept itself resists categorization. Again, even though defining this concept is difficult, researchers have investigated definable aspects of creativity. Researchers investigating creative thinking find little correlation between intelligence and creativity. Studies show that while we may agree in general about specific examples that demonstrate creativity, individual criteria for creativity vary widely. Most people's criteria do involve both originality and appropriateness. When judging whether or not something is creative, we look at whether it is original or novel and somehow fits the situation. Some researchers are investigating the distinctions between

convergent thinking, thinking pointed toward one solution, and *divergent thinking*, thinking that searches for multiple possible answers to a question. Divergent thinking is more closely associated with creativity. Creative activities usually involve thinking of new ways to use what we are all familiar with or new ways to express emotions or ideas we share. Painting by the numbers is convergent thinking, but we would probably call painting outside the lines and/or mixing your own hues creative and divergent thinking.

Practice Questions

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case.

1. Mr. Krohn, a carpenter, is frustrated because he misplaced his hammer and needs to pound in the last nail in the bookcase he is building. He overlooks the fact that he could use the tennis trophy sitting above the workbench to pound in the nail. Which concept best explains why Mr. Krohn overlooked the trophy?

   (A) representativeness heuristic
   (B) retrieval
   (C) functional fixedness
   (D) belief bias
   (E) divergent thinking

2. Phonemes and morphemes refer to

   (A) elements of telegraphic speech toddlers use.
   (B) elements of language.
   (C) building blocks of concepts.
   (D) basic elements of memories stored in long-term memory.
   (E) two types of influences language has on thought according to the linguistic relativity hypothesis.

3. Which example would be better explained by the levels of processing model than the information-processing model?

   (A) Someone says your name across the room and you switch your attention away from the conversation you are having.
   (B) You forget part of a list you were trying to memorize for a test.
   (C) While visiting with your grandmother, you recall one of your favorite childhood toys.
   (D) You are able to remember verbatim a riddle you worked on for a few days before you figured out the answer.
   (E) You pay less attention to the smell of your neighbor's cologne than to the professor's lecture in your college class.