“The 3 Box Model” of Memory Ch 8 nb

We may be top-notch learners, but if we don't have a way to store what we've learned, what good is the knowledge we've gained?

Take a few minutes to imagine what your day might be like if you could not remember anything you had learned. You would have to figure out how to get dressed. What clothing should you wear, and how do buttons and zippers work? You would need someone to teach you how to brush your teeth and tie your shoes. Who would you ask for help with these tasks, since you wouldn't recognize the faces of these people in your house? Wait . . . is this even your house? Uh oh, your stomach begins to rumble and you feel hungry. You'd like something to eat, but you don't know where the food is kept or even how to prepare it. Oh dear, this is getting confusing. Maybe it would be best just go back to bed. A bed. . . what is a bed?

We have an amazing capacity for memory, but how, exactly, do we process and store information? Are there different kinds of memory, and if so, what characterizes the different types? How, exactly, do we retrieve our memories? And why do we forget? This chapter will explore these questions as we learn about memory.

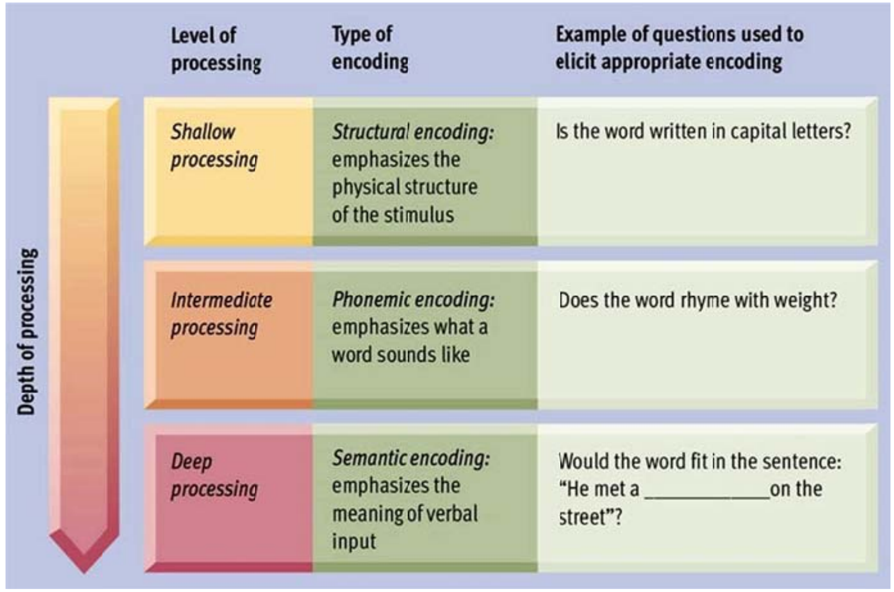
3 Box Model of Memory Storage

Although people usually refer to memory as a single faculty; as in "I must be losing my memory" or "He has a memory like an elephant's," the term memory actually covers a complex collection of abilities and processes. Video or movie cameras are not accurate metaphors for capturing these diverse components of memory because memory retrieval is a constructive process and does not necessarily represent what was actually put into memory. So then what metaphor would be better?

Many cognitive psychologists liken the mind to an information processor, along the lines of a computer, though more complex. They have constructed information-processing models of cognitive processes, literally borrowing computer programming terms such as input, output, accessing, and information retrieval. When you type something on your computer's keyboard, the machine encodes the information into an electronic language, stores it on a disk, and retrieves it when you need to use it. Similarly, in information-processing models of memory; we **encode** information (convert it to a form that the brain can process and use), **store** the information (retain it over time), and **retrieve** the information (recover it for use).

Levels of Processing

When we speak of the importance of encoding, we have to mention an older classic study by Craik & Tulving (1975). These researchers believed that HOW information is encoded determines how well it is retained. According the a Levels of Processing perspective, processing can occur along a continuum from shallow to deep. Shallow-level processing is primarily concerned with physical features—characteristics like the brightness or shape of an object, for instance. Deeper-level processing relies on characteristics related to patterns and meaning, and generally results in longer-lasting and easier to retrieve memories. So when you pay only a little attention to data entering your sensory system, shallow processing occurs, resulting in more transient memories. If you really contemplate incoming information and relate it to memories you already have, deeper processing occurs, and the new memories are more likely to persist (Craik & Tulving, 1975; Francis & Gutiérrez, 2012; Newell & Andrews, 2004). The more deeply you think about incoming information, considering its meaning or personal relevance, the greater success you will have learning and remembering it.



Fergus Craik and Endel Tulving explored levels of processing in their 1975 classic study. While presenting college students with various words on at a time, the researchers asked them yes or no questions, prompting them to think about and encode the words at three different levels: shallow, intermediate, and deep. The shallow questions required the students to study the appearance of the word: "is the word in capital letters"? The intermediate-level questions related to the sound of the word: "Does the word rhyme with 'weight"? And finally, the deep questions challenged the students to consider the word's meaning: "Is the word a type of fish?" or "Does the word fit into this sentence?"

When the researchers surprised the students with a test to see which words they remembered best, without any cues or clues, the students remembered best those words whose meaning they had thought about (Craik & Tulving, 1975). The take-home message: Deep thinking leads to firm memories (Foos & Goolkasian, 2008), particularly if you are trying to remember information with no cues for retrieval.

3 Boxes/Stages of Memory

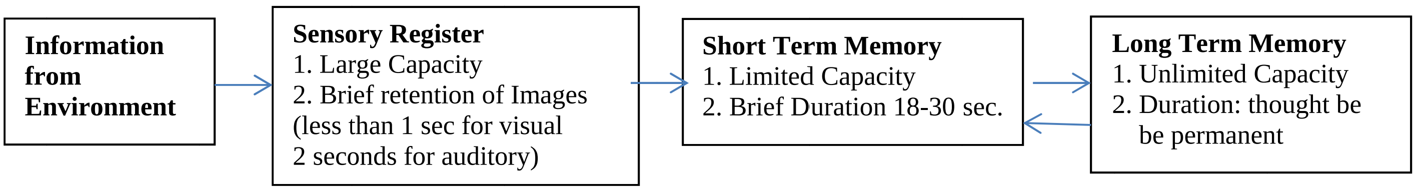
In most information-processing models, storage takes place in three interacting memory systems. A **sensory** register retains incoming sensory information for a second or two, until it can be processed further. **Short-term memory** (STM) holds a limited amount of information for a brief period of time, perhaps up to 30 seconds or so, unless a conscious effort is made to keep it there longer. **Long-term memory** (LTM) accounts for longer storage—from a few minutes to decades (Atkinson & Shiffrin, 1968, 1971). Information can pass from the sensory register to short-term memory, and in either direction between short-term and long-term memory.

This model, which is known informally as the "three-box model," has dominated research on memory since the late 1960s. However, critics of the model note that the human brain does not operate like your average computer. Most computers process instructions and data sequentially, one item after another, and so the three-box model has emphasized sequential operations; but the human brain performs many operations simultaneously, in parallel. It recognizes patterns all at once rather than as a sequence of information bits, and it perceives new information, produces speech, and searches memory all at the same time. It can do these things because millions of neurons are active at once, and each neuron communicates with thousands of others, which in turn communicate with millions more.

Because of these differences between human beings and machines, some cognitive scientists prefer a parallel distributed processing (PDP) or connectionist model. Instead of representing information as flowing from one system to another, a PDP- model represents the contents of memory as connections among a huge number of interacting processing units, distributed in a vast network and all operating in parallel—just like the neurons of the brain (McClelland, 1994; Rumeihart, McCleland, & the PDP Research Group, 1986). As information enters the system, the ability of these units to excite or inhibit each other is constantly adjusted to reflect new knowledge.

Memory researchers are still arguing about which model of memory is most useful. We emphasize the three-box model, but keep in mind that the computer metaphor that inspired it could one day be as outdated as the metaphor of memory as a camera.

The Three Box Model of Memory



The information model of three separate memory systems—sensory, short-term, and long-term—remains a leading approach because it offers a convenient way to organize the major findings on memory, does a good job of accounting for these findings, and is consistent with the biological facts about memory. Let us now peer into each of the "boxes."

The Sensory Register: Fleeting Impressions (Iconic for vision and Echoic for hearing)

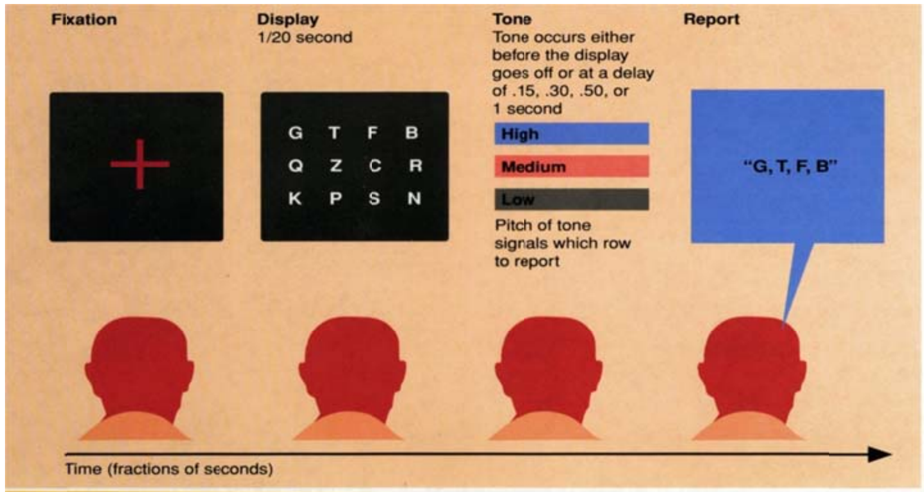
In the three-box model, all incoming sensory information must make a brief stop in the sensory register, the entryway of memory. The sensory register includes a number of separate memory subsystems, as many as there are senses. Visual images remain in a visual subsystem for a less than a second. Auditory images remain in an auditory subsystem for a slightly longer time, by most estimates up to two seconds or so.

The sensory register acts as a holding bin, retaining information in a highly accurate form until we can select items for attention from the stream of stimuli bombarding our senses. It gives us a brief time to decide whether information is extraneous or important; not everything detected by our senses warrants our attention. Information that does not quickly go on to short-term memory vanishes forever, like a message written in disappearing ink.

The bulk of information entering sensory memory comes and goes like the images on a movie screen. A few things catch your attention—the beautiful eyes of someone, the sound of a voice, and perhaps the color of a shirt—but not much more before the frame switches and you're looking at another image. Information floods our sensory memory through multiple channels—what we see enters through one channel, what we taste through another, and so on.

<u>More is seen than can be remembered: Iconic Memory</u>: Interested in how the brain processes data entering the visual channel, Harvard graduate student George Sperling (1960) designed an experiment to determine how much information can be detected in a brief exposure to visual stimuli. Sperling set up a screen that flashed multiple rows of letters for one-twentieth of a second, and then asked participants to report what they saw.

His first goal was to determine how many letters the participants could remember when an array of letters (for example, three rows of 4 letters) was flashed briefly; he found that, on average, the participants only reported 4 letters. But Sperling wasn't sure if this meant they were only able to store one row at a time in their memory (capacity limitation), or if they stored all the rows at once, but just not long enough to recite them before they were forgotten (duration limitation).



Sperling was convinced that "more is seen than can be remembered" (1960, p. 1), so he devised a clever method called partial report to provide evidence (1960, p.1). As with the original experiment, he briefly flashed an array of letters (for example, three rows of 4 letters), with all rows visible. But instead of having the participants report what they remembered from all the rows, he asked them to report what they remembered from just one row at a time. Here's how the study went: The array of letters was flashed, and once it disappeared, a tone was sounded. When participants heard a high-pitched tone, they were to report the letters in the top row; with a medium-pitched tone, the letters in the middle row; and with a low-pitched tone, the letters in the bottom row. The participants were only asked to give a partial report, that is, to report on just one of the rows, but they did not know which row ahead of time. In this version of the study, the participants performed very well, recalling approximately 76% of the letters. They doubled their performance with the partial report method, suggesting that more can be seen than is remembered—even though these memories last less than 1 second (Sperling, 1960). Sperling's research suggests that the visual impressions in our sensory memory, also known as iconic memory, are photograph-like in their accuracy but dissolve in less than a second.

Eidetic Imagery: Perhaps you have heard friends talk about someone who claims to have a "photographic memory" that can record and store images with the accuracy of a camera: "My cousin can look at a textbook page, remember exactly what it says in a few seconds, and then recall the information days later, seeing the pages exactly as they were." That may be what your cousin claims, but is there scientific evidence to back up such an assertion? We doubt it.

According to some reports, though, researchers have documented a phenomenon that comes fairly close to photographic memory. It's called eidetic imagery (i-'de-tik), and those who have this ability can "see" an image or object for as long as several minutes after it has been removed from sight, describing its parts with amazing specificity. However, the details they "see" are not always accurate, and thus their memories are not quite "photographic." Eidetic imagery is rare and usually only occurs in young children (Searleman, 2007).

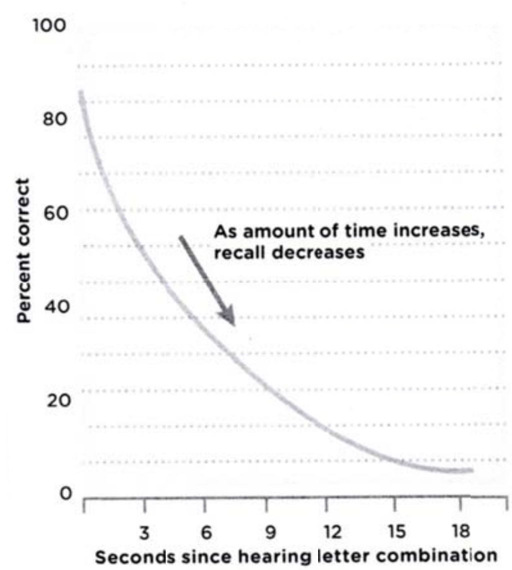
Echoic Memory: Exact copies of the sounds we hear linger longer than visual impressions; echoic memory (oh-ko'-ik) can last from about 1 to 10 seconds (Lu, Williamson, & Kaufman, 1992; Peterson, Meagher, & Ellsbury, 1970). Research has shown that the introduction of a single tone played for 300 milliseconds initiates changes in cortical activity (Inui et al., 2010). Even if you are not aware of it, your auditory system is picking up slight changes in stimuli and storing them in echoic memory for a brief moment, so you don't have to pay attention to every incoming bit of auditory information. Perhaps you have had the following experience: During class, your instructor notices a classmate daydreaming and tries to bring him back to reality: "Eddy, could you please restate the question for us?" He might think that he hadn't heard the question because he was daydreaming and he says "huh?". As the professor starts to re-ask the question, Eddy's mind recognizes that the professor's question is actually still there in his sensory store, his echoic memory, and he answer's the professor's question. For this, he can thank his echoic memory. The professor however, may say, If you heard me the first time, why did you say "huh?".

Although brief, sensory memory is critical to the creation of memories. Without it, how would information enter the memory system in the first place? We have discussed iconic and echoic memory, which register sights and sounds, but memories can also be rich in smells, tastes, and touch. Remember, data received from all the senses are held momentarily in sensory memory. And although the bulk of research has focused on iconic and echoic memories, psychologists propose that we also have similar sensory stores for the other senses.

Now that we have examined the initial sensory and perceptual experiences captured in sensory memory, let's move to the next stage of the information-processing model: short-term memory.

Short Term Memory

When information enters your sensory memory, it does not linger. So where does it go next? If not lost in the overwhelming array of sensory stimuli, the data proceed to short-term memory, the second stage in the information-processing model proposed by Atkinson and Shiffrmn (1968). The amount of time information is maintained and processed in short-term memory depends on whether you are distracted by other cognitive activities, but the duration can be about 18 seconds (Atkinson & Shiffrin, 1968).



In a classic study examining the duration of short-term memory, an experimenter recited a three-letter combination, followed by a number. Participants were then asked to begin counting backward by 3 from the number given (if the experimenter said, "CHG 300," then participants would respond, "300, 297, 294. . .") until they saw a red light flash, which signaled them to repeat the three-letter combination. After 3 seconds of counting backward, participants could only recall the correct letter combinations approximately 50% of the time. Most of the participants were unable to recall the letter combination beyond 18 seconds (Peterson & Peterson, 1959). Why do you think it was so hard for them to remember? Think about what you normally do if you're trying to remember something; you probably say it over and over in your head (CHG, CHG, CHG). But the participants were not able to do this because they had to count backward by 3s, which interfered with their natural inclination to mentally repeat the letter combinations.

What this experiment reveals is that short-term memory has a limited duration.

<u>The Leaky Bucket: What is the capacity of STM?</u> According to most memory models, if the bucket did not leak it would quickly overflow, because at any given moment, short-term memory can hold only so many items. Years ago, George Miller (1956) estimated its capacity to be "the magical number 7 plus or minus 2." Five-digit zip codes and 7-digit telephone numbers fall conveniently in this range; 16-digit credit card numbers do not. Some researchers have questioned whether Miller's magical number is so magical after all; estimates of STM's capacity have ranged from 2 items to 20, with one recent estimate putting the "magical number" at around

4 (Cowan, 2001). Everyone agrees, however, that the number of items that short-term memory can handle at any one time is small.

If this is so, then how do we remember the beginning of a spoken sentence until the speaker reaches the end? After all, most sentences are longer than just a few words. According to most information-processing models of memory, we overcome this problem by grouping small bits of information into larger units, or chunks. The real capacity of STM, it turns out, is not a few bits of information but a few chunks. A chunk maybe a word, a phrase, a sentence, or even a visual image, and it depends on previous experience. For most Americans, the acronym FBI is one chunk, not three, and the date 1492 is one chunk, not four. In contrast, the number 9214 is four chunks and IBF is three—unless your address is 9214 or your initials are IBE. To take a visual example: If you are unfamiliar with football and look at a field full of players, you probably won't be able to remember their positions when you look away. But if you are a fan of the game, you may see a single chunk of information—say, a wishbone formation—and be able to retain it.

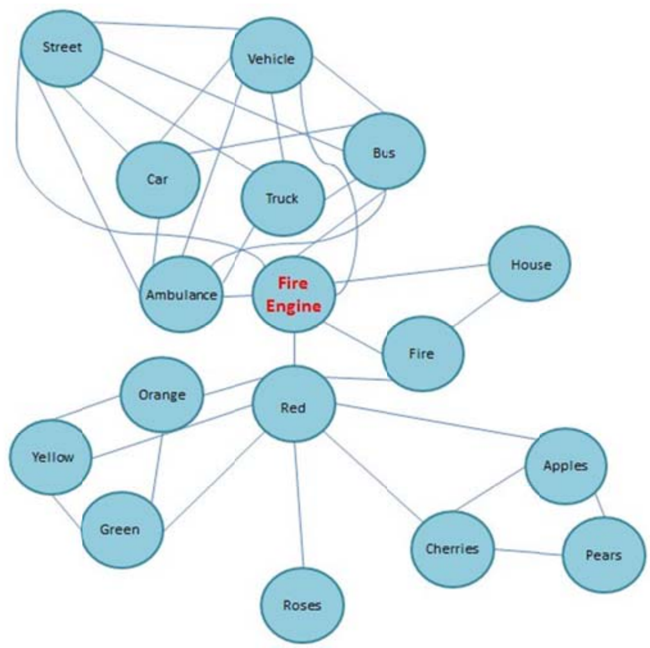
Even **chunking** cannot keep short-term memory from eventually filling up. Fortunately, much of the information we take in during the day is needed for only a few moments. If you are multiplying two numbers, you need to remember them only until you have the answer. If you are talking to someone, you need to keep the person's words in mind only until you have understood them. But some incoming information is needed for longer periods and must be transferred to long-term memory. Items that are particularly meaningful, have an emotional impact, or relate to something already in long-term memory may enter long-term storage easily, with only a brief stay in STM. The destiny of other items depends on how soon new information displaces them in short-term memory. Material in short-term memory is easily displaced unless we do something to keep it there. Of course, **maintenance rehearsal** can do just that – keep it there. That is what you do when you have a phone number you want to remember while you search for something to write it down.

Long Term Memory: The Final Destination

The third box in the three-box model of memory is long-term memory (LTM). The capacity of long-term memory seems to have no practical limits. If you have trouble recalling something from LTM, it is assumed you can't locate it in memory, rather than it not being there. The vast amount of information stored there enables us to learn, get around in the environment, and build a sense of identity and a personal history.

Organization in Long-term Memory. Because long-term memory contains so much information, it must be organized in some way, so that we can find the particular items we're looking for. One way to organize words (or the concepts they represent) is by the semantic categories to which they belong. Chair, for example, belongs to the category furniture. In a study done many years ago, people had to memorize 60 words that came from four semantic categories: animals, vegetables, names, and professions. The words were presented in random order, but when people were allowed to recall the items in any order they wished, they tended to recall them in clusters corresponding to the four categories (Bousfield, 1953). This finding has been replicated many times.

Evidence on the storage of information by semantic category also comes from cases of people with brain damage. In one such case, a patient called M. D. appeared to have made a complete recovery after suffering several strokes, with one odd exception: He had trouble remembering the names of fruits and vegetables. M. D. could easily name a picture of an abacus or a sphinx, but he drew a blank when he saw a picture of an orange or a carrot. He could sort pictures of animals, vehicles, and other objects into their appropriate categories but did poorly with pictures of fruits and vegetables. On the other hand, when M. D. was given the names of fruits and vegetables, he immediately pointed to the corresponding pictures (Hart, Berndt, & Caramazza, 1985). Apparently, M. D. still had information about fruits and vegetables, but his brain lesion prevented him from using their names to get to the information when he needed it, unless the names were provided by someone else. This evidence suggests that information about a particular concept (such as orange) is linked in some way to information about the concept's semantic category (such as fruit).

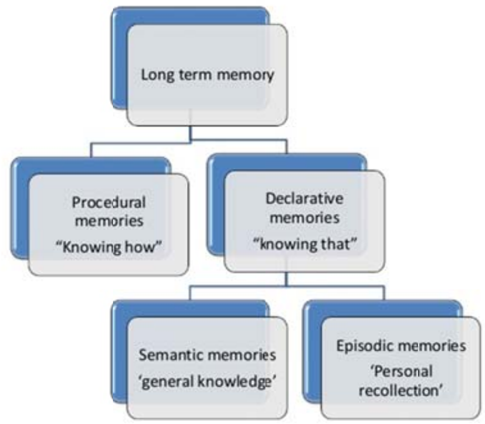


Indeed, many models of long-term memory represent its contents as a vast network of interrelated concepts and propositions (Anderson, 1990; Collins & Loftus, 1975). These models have been called "semantic network" models, or "spreading activation" models. In these models, words/constructs/nodes are connected. The more 2 words are associated in the real world, the closer they are in the network. When I mention a word, it is assumed that energy spreads out into the network from that word, much like ripples on a pond. The farther the ripples travel, the weaker they become. So for example, if I say the word "Truck" and ask you to say the first word that comes into your mind, you might say "Bus" because truck and bus are very closely related. You would be less likely to respond with "Roses" because that node is farther away. However, this model assumes that even though "Roses" might not get enough activation to enter consciousness (and be vocalized), it still could receive some "sub-threshold" activation. This might make it seem like it is on the "tip-of-the-tongue".

This spreading activation model does a good job of explaining "priming effects". If you were sitting at a computer screen and I flashed the word "truck" (called a prime word because we only want to see if it influences you) and next flashed the word "bus" (called the target word because we want you to respond to it) and asked you to decide if "bus" was a word or not, you would be quicker to say yes, than if the we had primed you with a word that is not as close in the network (for example "green"). The explanation is that once you see the prime word (truck), activation spreads to related words and even if the activation is too weak to bring the target word into consciousness, it might be like, half way there. That would make it quicker for you then, to process the target word in some way.

<u>The Contents of Long-term Memory.</u> Most theories of memory distinguish skills or habits ('knowing how") from abstract or representational knowledge ("knowing that"). Procedural memories are memories of knowing how to do something—for example, knowing how to comb your hair, use a pencil, solve a jigsaw puzzle, knit a sweater, or swim.

Declarative memories, in turn, come in two varieties, semantic memories and episodic memories (Tulving, 1985). **<u>Semantic memories</u>** are internal representations of the world, independent of any particular context. They include facts, rules, and concepts—items of general knowledge, often stuff that you learn in school. On the basis of your semantic memory of the concept cat, you can describe a cat as a small, furry mammal that typically spends its time eating, sleeping, prowling, and staring into space, even though a cat may not be present when you give this description, and you probably won't know how or when you first learned it. **<u>Episodic memories</u>** are internal representations of personally experienced events. They are “time-dated”. When you remember how your cat once surprised you in the middle of the night by pouncing on your face as you slept, you are retrieving an episodic memory. The figure at the right summarizes these kinds of memories.



<u>Implicit vs Explicit Memory</u>

A number of texts (including ours in 8.1 under heading “long term memory) talk about implicit and explicit memory as if they are distinct memory systems. In fact our text says that skills and actions in procedural memory are “not part of our consciousness”. I would disagree because yes, we can tie our shoe without much conscious awareness of exactly how we are doing it, but on the other hand, that material COULD be in conscious awareness if we wanted to focus on it. So the problem I have with our text (and some others) is that: If implicit and explicit are different systems, how can a memory be in both? A memory can’t be in both semantic and episodic!!

I think a better way of thinking is that the memory itself isn’t implicit or explicit but the <u>method</u> we use to retrieve the memory is either an implicit or explicit memory test. Let’s say I give you 20 words one-at-a-time. Then I ask you recall as many as you can. That request is an explicit memory test because I am asking you to directly report on what is stored in memory using your conscious awareness. I could, however, get at that information by not directly asking you, but by using an Implicit memory test (for examples of these tests, read the handout “implicit measures”.) For example, I could ask you to complete word fragments. Assume one of the words in the list was “weed”. I ask you to complete the fragment “W _ _ D”. You could complete this many ways, but what if most people given the 20-word list complete it as WEED? Does that not mean that they saw the word “weed” in the list and are telling me that even with me not directly asking them?