I. PRINCIPLES OF MEMORY[1]

Memory is a vital function supporting learning, consciousness, cognition and behavior. Yet most people have little grasp of how memory works, its real purpose, or how remembered information relates to actual past events. Most laypersons believe memory functions to provide conscious knowledge of the past. Memory researchers, however, view memory as guiding current behavior based on past experience. Conscious knowledge may be a side effect, or one means to achieve behavioral guidance, but is not the real objective of the system. From this viewpoint, forgetting and other memory "failures" illuminate normal function in the same way visual illusions reveal normal visual function. They are not mere inefficiencies but are the infrequent down-side of powerful heuristics that guide current behavior with minimal load on working memory and attention.

Most laypersons over-apply the popular computer model of memory. They believe encoding is encyclopedic and very detailed. They also believe "storage" is static retention of information, largely unchanged until recalled. Further, they believe that recall is mainly determined by the past events. Research indicates otherwise.

Attentional limits dictate that we encode little of our experience. "Storage" is not static, as on a hard drive. Our memory is updated after-the-fact with context and real world knowledge to improve future behavior. This updating often protects us from harm, but does not always increase accuracy. It can, under some conditions, result in forgetting or in false memory of details or entire events that never occurred. Finally, recall depends on one's current context as much or more than on the past events themselves. Recall is not a search for the exact reproduction of an event. It is a reconstruction of the event based on fragments of encoded, updated, and inferred information, subject to constraints of the recall situation.

This misunderstanding of memory leads to poor evaluation of memories in certain instances. For example, humans tend to believe a vivid detailed, emotional accusation is either accurate or else fabricated. They do not consider the third possibility: Reasonable, normal people can have detailed, vivid memories they firmly believe, which are nonetheless entirely (or partially) false, even concerning important events and issues. To understand how this might occur, let us review memory function.

Memory Overview

Encoding

Most information is only encoded while directly attended, with our limited-capacity attention system. The Illinois Door Study demonstrates how surprisingly little we actually encode. Each subject was approached and asked directions by an experimenter. Two confederates then carried a door between the conversants. Another confederate changed places with the experimenter as the door passed, and continued the conversation. Half the subjects did not notice the mid-conversation person change! Apparently, we often encode only basic information such as "direction asker" about people. We may not notice clothing, height, and hairline change because they were not attended. Subsequent studies indicate that we notice such changes, given an adequate hint soon

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[1] Excerpts from Raymond Phinney: "*Malleability of Memory: Evaluating Testimony and Accusations within the Mission Community*." Chapter in *The Missionary Family: Witness, Concerns, Care*. Editors Dwight P. Baker, Robert J. Priest. William Carey Publishing, Aug 29, 2014.

enough after the switch, but that information decays quickly. Only information that is attended and rehearsed is ultimately translated into semantic information (meaning) for later recall.

Repetition powerfully strengthens memories but has diminishing returns. Each repetition adds less strength than the last. More processing is better, but the type of processing is also critical in determining memory strength. In the "levels of processing" theory, "deeper" cognitive processes support better memory. Craik and Tulving had participants judge words in a list and then administered an unexpected memory test for the words. Those judging visual appearance (e.g. "Is this word in all capitals?) remembered few words. Acoustic judgments ("Does this word rhyme with dog?") yielded better memory. Semantic judgments (e.g. "Does this word complete the sentence?") yielded the best memory. **Memory seems to be optimized to retain meaning, not the sensory information itself.** Deeper (semantic) processes improve memory regardless of whether the subject intends to remember. Motivation effects do not directly affect recall. Rather, higher motivation causes more and deeper processing, improving recall.

Encoding is thus the transforming of a small subset of the sensory information from an event into a semantic code for retention. The limited nature of encoding necessitates updating in storage and reconstruction at recall to yield a complete narrative of past events.

Storage

Information is not simply warehoused between encoding and retrieval, but updated. **Originally encoded information is supplemented with information from later similar events, others' accounts of that or similar events, mentally reliving the event, or even imagining such events.** All possible sources of information are used to make a memory as detailed and accessible as possible for later use.

Storage is semantically organized. Information about a certain meaning is stored together, regardless of when the different information was obtained. So we often "remember" experiencing something during our first exposure to an event, even if we only learned about that facet of the event later.

Amnesia studies have revealed much about memory. Bilateral hippocampal damage leaves patients unable to form new **declarative memories** after the injury. Memory for days to decades predating the damage is impaired, depending on severity of the damage. Earlier memories are unimpaired. Thus, post-injury events and the more recent pre-injury events cannot be consciously recalled. However, **non-declarative memory** – skills, habits, conditioning, and priming which do not require conscious recall – is typically unaffected. These results indicate the hippocampus is essential to declarative memory encoding and is also required for conscious recall until the memory is fully consolidated, days to decades after the event. However, the hippocampus does not itself hold those memories. **Memory elements are distributed throughout cortex; visual elements in visual cortex, auditory information in auditory cortex, etc. The hippocampus consolidates, or binds those elements together for later combined recall.**

In addition to consolidating a single event, the hippocampus reconsolidates it each time it is recalled. **During reconsolidation the memory can incorporate new information and is therefore vulnerable to change or even deletion.** In rats, hippocampal disruption (with shock or protein synthesis inhibitors) shortly after recall destroys the memory. Distraction may disrupt reconsolidation in a similar fashion, but to a lesser degree. This vulnerability, a seeming weakness, is also a strength. The lability allows incorporation of new information into the memory. This is adaptive because one may only understand an event sometime after it occurs. Storing the later

understanding with the original memory improves future responses. Without updating, memories could not incorporate new information, nor could a first impression be revised.

Non-activated memories decay or become less accessible over time. Decay is one way we forget. Rehearsing or using information builds memory strength, combating decay. Decay is functional in that unused information may be old and no longer relevant. Losing it allows concentration of limited resources on processing current, relevant information. If I remember, with equal intensity, every item I ever ran out of while at the supermarket, I would be as lost as if I had no memory. I want to best recall items depleted most recently.

Levels of processing also affect retention. **Deeper, semantic information is retained longer than shallower, sensory information.** Thus we cannot simply "replay the video" to recall events. **We retain the meanings of sensory information, but not the sensory information itself**. It decays quicker than semantic information unless carefully, explicitly rehearsed. Anderson demonstrated this differential decay. Subjects read paragraphs of eight sentences, each concerning two agents and one action in either passive or active voice. Consider:

1) The painter shot the actor.
2) The actor was shot by the painter.

The action is the same in each, but 1 uses active voice and 2 uses passive voice. Paragraphs contained four active and four passive sentences. Subjects then reported which test sentences had been verbatim in the paragraph. Subjects verified both action and voice 98% correctly with no delay. With two minutes delay, subjects falsely recognized sentences in the wrong voice provided they referenced the right action. Acoustic representation of the sentences had decayed while semantic representation was still strong.

In summary, **retained information is updated, not static**. **Sensory information decays quickly, leaving mostly semantic information**. Furthermore, updating can lead to enhancement or deletion of memories. Updating can be adaptive, but can also be a source of errors. Misinformation experiments, discussed in the Reconstruction section, elucidate how such errors may occur. See the "Memory Concepts" section of this handout for a more detailed description of sensory, short-term, and long-term memory.

Retrieval

To be used, information must be retrieved, either automatically or effortfully. Much everyday recall is automatic retrieval. Semantic priming is an example whereby a stimulus (the prime) facilitates activation of a semantically related stimulus (the target). Primed targets are recognized faster than unprimed targets. For instance, people recognize dog as a word more quickly following puppy (a semantically related word) than following lramn (a non-word) or blanket (a semantically unrelated word).

Priming occurs through mental associations other than semantic relation, such as temporal contiguity or even arbitrary association. Paired-list recall demonstrates this. Subjects who studied paired-lists later recalled the second word of each pair, given the first as a retrieval cue, better than they could recognize the second words in a recognition list. Recognition is typically better than recall. However, in this case, subjects' word recall exceeded recognition because the first words primed activation of the second words. Pairing the semantically unrelated words caused subjects to associate them.

Priming can even occur with no explicit pairing. After learning lists derived from certain categories, subjects remember more words when the category names are provided at recall as retrieval cues. Subjects not given category names at the first recall can remember more words at

a second recall if given the category names. Thus, forgotten items are often available in our memory but are not accessible at that time or under those conditions. Furnishing more effective retrieval cues can improve recall.

Priming does occur in everyday life. Seeing something often primes recall of the last time we saw it. Next, memory of related information is primed, such as whom we were with or what happened next. Looking at our old yearbook pictures primes recall of names and events we could not otherwise retrieve that day.

Context effects are strong memory phenomena that depend on temporal association. The context in which we learn an item is automatically associated with that item. When the retrieval context (environmental, mental and physical conditions) is similar to the encoding context, recall is facilitated for items encoded in that context. For instance, people who learned word lists on land or underwater remembered more words if tested in the same condition. Subjects recalled more words when the encoding and recall contexts were the same (land-land or water-water conditions) than when they were different (land-water or water-land conditions).

State dependent memory yields enhanced recall when internal state (e.g. inebriation versus sobriety) **is similar at encoding and recall**. In a related effect, **mood dependent memory, enhanced recall occurs when mood is similar at encoding and recall**. Another mood effect, mood-congruent memory, entails enhanced recall when the items' meanings are congruent to one's current mood.[15] Depressed persons often exhibit both effects, better recalling information encoded while depressed (mood dependence) and information with a depressing meaning (mood congruence). Mood-incongruent memory, enhanced recall of items with opposite meaning from one's current mood, can occur when a professional or non-emotional demeanor is demanded. For instance, graduate students exhibited mood congruent recall at the end of class (under no demand for professional demeanor), but mood-incongruent recall at the beginning of class, when ongoing professional demeanor is expected. Such mood regulation further highlights that memory is more about present behavior guidance than about conscious knowledge of the past.

These context effects strongly influence recall, highlighting the role of retrieval cues in remembering. Recall relies crucially on current environment, not just past events. **Retrieval cues and proper retrieval contexts are necessary for successful recall.** These effects can affect both automatic and effortful recall. One can try to remember past events by trying to imagine or even go to the encoding context. When the retrieval context matches the encoding context and more detail is accurately remembered, it is termed **context dependent memory**, but the recall context exerts an effect whether or not it matches the encoding context. Context effects are so strong that they can warp memory as well. In an angry state, one is more likely to remember a given event as containing angry words, for instance. One must be quite sure of the original context to accurately improve recall.

Reconstruction

The concept of retrieval usually evokes a search analogy, such as for an artifact – a detailed, accurate, unchanged representation of a past experience. No such representation exists. **Recall is not retrieval of a faithful reproduction of the event. Recall involves reconstructing the event from limited, stored information, updated information, current knowledge, and context**.

How does reconstruction fill-in the encoded, updated information with useful, accurate information? It does so through real world knowledge, for instance with invariants. Much of the perceptual information we receive remains invariant as we move through the environment. (For instance, the earth is always below, the sky above, light comes from above, etc.). Humans abstract and use such invariants to navigate and judge distances. Similarly, invariants economize our

information processing and storage. We need not store every aspect of an experience because certain attributes tend to covary with others. Storing them all is inefficient. Studies like the Illinois Door Study demonstrate that we store fewer details than we suppose. Reconstruction capitalizes on context and invariants to supply missing information that is usually correct. Sometimes, however, this economy leads to inaccuracy.

An example of reconstruction error is the **misinformation effect**. Loftus and Palmer had participants answer questions immediately after watching video of low-speed car crashes with no vehicle damage. One group was asked to estimate the vehicles' speed as they "hit" each other. The verb for the other group was "smashed." One week later, the "smashed" group was twice as likely as the "hit" group, or a control group, to falsely report seeing broken glass at the scene. This minor wording change distorted later memory of crash severity. Reconstruction is always part of the recall process, but can only be definitively demonstrated when "recalling" details not in the original event, since any correctly remembered details could be due to accurate encoding, storage, and retrieval or from reconstruction.

People can even come to remember entirely false events such as getting lost as a child at a Disney park and being found by Bugs Bunny, or seeing a non-existent video of an event they know happened – such as the No. 30 bus explosion in the 2005 London Tavistock Square bombing. **False memories become even more detailed and vivid when subjects are encouraged to simply talk about whether the supposed event might have happened, as one may do in psychotherapy or recovery groups**. Over successive sessions, subjects "recall" more detail and develop more emotion about the false event. Those memories then become indistinguishable from true memories as judged by the rememberer and by third parties.

Some proponents of recovered memory therapies contend these experiments do not involve the intensity and personal nature of sexual abuse. Such trauma, they argue, causes memory mechanisms to function differently, sparing it from misinformation or suggestion effects. However, there have been recent experiments using personal, threatening events (which elevated cortisol and norepinephrine and suppressed gonadal hormones) in an army mock POW camp at Survival Training School. Well trained individuals misidentified their interrogator 93% of the time when given misinformation (such as a picture or a description of an interrogator) versus 50% of the time when not misinformed. Participants in the mock POW camp were physically, emotionally, and verbally abused by their interrogators under severe duress and were required to look at interrogator's faces at all times. Yet when misinformed, they could not identify them properly. Clearly stress did not spare those memories from distortion. It should be noted that the army's own estimate of unreported rapes within its ranks is about 19,000 per year. Thus, any soldier might reasonably fear sexual violence at any time in service. It is therefore unlikely that the stress of the mock POW camp is categorically different than that experienced in sexual trauma.

Merely imagining an event increases false recall and increases one's confidence in the accuracy of such a memory. Garry, Manning, Loftus and Sherman gave participants life-event inventories and two weeks later asked them to imagine an event – such as falling through a window and cutting their hand. Different groups imagined different events. Participants then completed a second life event inventory (they were told the first had been lost). More subjects recalled the imagined event as real in the second inventory with no change in other reported event frequencies. **Imagination increased familiarity, which can increase belief in a statement's truth, even if the familiarity comes from mere exposure to the statement with no fact-checking**.

Finally, search, retrieval, and reconstruction are shepherded by cognition. This is undoubtedly why retrieval context has such a powerful effect. Environment and internal state affect cognitive

state, affecting priming and reconstruction into a full memory. Researchers refer to this as "**retrospective bias**". At retrieval, it seems the left prefrontal cortex generates possible missing information about events that are difficult to recall from simple hippocampal retrieval. Right prefrontal cortex performs plausibility checking by reconstructing the original context and filtering out possible answers that are not relevant for the given context. This plausibility checking gives us a sense of how confident we are in the accuracy of a memory.

II. MEMORY "*FAILURES*"

False and distorted recall due to misinformation is but one kind of memory error. Daniel Schacter has classified memory failures into seven "sins" of memory. **Transience, absentmindedness, and blocking are sins of omission or forgetting. Suggestibility, bias, misattribution, and persistence are sins of commission in which something is remembered intrusively or inaccurately.** Schacter argues these "sins" are not errors, but rather the infrequent down-sides of adaptive trade-offs that give us efficient, useable memory systems. They indicate that memory's function is not to produce conscious access to detailed knowledge of our past but to guide current behavior using past experience without exhausting limited resources of attention and information processing. Systematic study of these failures illuminates normal memory function the same way study of visual illusions informs us about visual function.

Transience is the loss of unused, old information via decay. As mentioned in the Storage section, such loss is useful when the information is no longer accurate. Interestingly, decreased likelihood of recalling old, unused information mirrors the actual probability with which information recurs in the environment. Anderson and Schooler found the probability of words recurring in the New York Times and in emails in a database followed the same mathematical function as human recall probability over a similar retention interval. Our forgetting curve seems to yield optimal adaptation to the environment.

Absent-mindedness is forgetting information that was not properly attended at encoding. Settling an argument between my kids upon arriving home interrupts my normal arrival routine and I may not place my keys in the usual place. My diverted attention is not on key placement, which is quickly forgotten. This seems a failure but points out an efficient rule. Given limited processing capabilities, it is best to limit and prioritize what is actually encoded and stored. Unattended information is often unimportant and unlikely to be useful later. The downside? If I am distracted, something may be unattended and not be properly encoded.

Blocking is failure to recall encoded information such as the inability to put a name to a familiar face. This often occurs for someone we have not met or thought of recently. Given limited resources, it is best to prioritize strengthening only activated memories. Transience is the downside of maintaining only information that is most current. Absent-mindedness is the down side of selective encoding, and blocking shows that some information is less accessible as it gets old or unused.

Suggestibility is distortion of a memory based on post-event misinformation. It is the downside of updating. Improving memory with post-event information can improve one's response to future events. This is the adaptive genius of a semantically organized system with reconsolidation and updating. Post-event information usually further clarifies what happened or how to respond in future instances. Sometimes, however, post-event information can be misleading as in the Loftus and Palmer study. An inference from a single word change in post-event questions was stored with the representation of the actual collision, since both concerned the same event. This led to distorted recall later.

Misattribution is attributing information to the wrong source. Suggestibility in the Loftus and Palmer study was caused by misattributing the source of the inference. It came from the word "smashed" in a post-event question, but was attributed to observation of the accident. Similarly, leading questions, poor interviewing technique, and repeated interviewing can distort eyewitness testimony. Even careful

questioning may cause distortions. The effect has been shown for a single word that was not in a statement but in an inquiry. Misattribution is one reason that imagination inflation occurs and some false memories form. In recall following imagination, subjects misattribute images from the imagination task as having occurred at an actual event. Researchers refer to this as "**source monitoring errors**".

Bias is memory distortion due to one's expectations. Since memory is semantically organized, the similar meaning of one's expectations and one's actual observations at an event are difficult to separate in later recall. Sometimes, one's understanding of what occurred at an event is based on one's erroneous expectations. The belief is misattributed as due to observations at that event, when it is really due to pre-event expectations, not something that actually occurred. Also, expectations guide attention. Proper expectation leads to a focus on the most important things, facilitating memory for them. Misplaced expectations can bias one's memory for the meaning or details of an event, especially complex or vague events that lack clear constraints that could direct attention to the most important information.

Persistence is intrusive, unwelcome, recall, such as occurs in post-traumatic stress disorder (PTSD). It also occurs after non-life-threatening stresses such as an office argument. Afterwards, mining that experience to optimize future responses to comparable situations is quite functional. This involves thinking about, analyzing, and modeling how things might have gone differently. The possible downside to reliving these experiences is that some people in some conditions experience stressful over-arousal while reliving the event. Rather than habituating to the trauma, they are sensitized to it. The prevalence of PTSD indicates that trauma most commonly triggers persistence, not repression or forgetting. In fact, contrary to many memory recovery proponents' claims, sexual trauma is not more easily forgotten than other events. It is by far better remembered, especially if it is violent, significant, or repeated over time.[29]

Schacter declares that these "sins," taken together, are not failures of the system, but rather the costs of an adaptive and efficient system. If the system's purpose were encyclopedic knowledge of one's past, then it is inefficient and untrustworthy at points. But reverse engineering the system through studying memory capabilities and limits indicates its purpose is rather to guide present behavior using knowledge from previous events, whether it is conscious and effortful or automatic.

Consequences for remote autobiographical memory

So what does all this mean for ones memory of one's own past? **There are two types of long-term declarative (conscious) memory: semantic and episodic. Semantic memory concerns facts we know. Episodic memory concerns the episodes of our life and the flow of events within them.** I remember that Columbus sailed westward through the Atlantic on the Nina, the Pinta, and the Santa Maria. This is a semantic memory. I also remember my kindergarten teacher telling the story as we colored a picture of 3 ships on the sea. That is an episodic memory. I can choose to think about either and thus rehearse them, but whereas I can verify the truth of the ship names, I cannot really verify all the details of what happened in class that day. Thus, rehearsal can have a very different effect on semantic than on episodic memory. **Semantic memory is less susceptible to distortion through misinformation, suggestion, and context effects. Episodic memory is typically less often and less reliably rehearsed than semantic memory**.

For instance, when asked what I did on the morning of September 11, 2001, I have some idea because I thought about and told others about those events repeatedly just after they occurred and sporadically since. However, when asked about September 10, 2001, I really have no clear memory of that. I do not recall ever recounting those events to anyone. Likely, no one ever asked. Although my 9/11 memory got more rehearsal than my 9/10 memory, is the former more accurate than any other (well rehearsed) memory? It is an example of a flashbulb memory, memory for an important and emotional event.

The vividness of such long-past memories was once thought to demonstrate their accuracy and permanence. However, such recall has since been repeatedly demonstrated to be malleable. Change has been demonstrated regarding the announcement of the O.J. Simpson murder verdict, the Challenger space shuttle explosion, and 9/11 terrorist attack. **Participants' narratives concerning how they heard, who told them, where they were when they found out, and other central information (as well as details) changed over a 9 to 18 month period. Even though the stories changed, participants expressed very high confidence in their accuracy.**

Why do these stories change if they are so important to us and we retell them all the time? Marsh says retelling is not the same as recalling. Retelling of an event is aimed to affect the listener, not practice complete and accurate recall. A retelling may omit details that are "boring," complicate the story, negatively characterize the speaker, or otherwise detract from the desired effect. Untold details are rehearsed less and may become irretrievable. The speaker may then reconstruct details if asked questions about missing information. The reconstructed details may be items for which the reteller has source amnesia and has misattributed to that event. Some details may be overemphasized, leading to later exaggeration of details or of the importance of one event versus another. Or, the speaker may misattribute and remember some aspect of a retelling as being something that actually occurred in the event**. Thus, one is much more likely to be inaccurate about episodic than semantic information. Without the ability to verify the facts, an often retold or remembered story can change, even on the main points.**

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Experiencing and Remembering

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Memory connects our past to our present and involves translating our experiences into a representation that can later influence our behavior or contribute to a recollection. Furthermore, although we may spend a lot of time in school deliberately trying to learn information well enough to remember it later, this is not how we go about remembering most things in our lives. Instead, our brains appear tuned to help us make sense of what is happening around us and provide predictions about what is going to happen next (e.g., Bar, 2007). It is important to understand that the perceptual and reflective processes that help us comprehend an event not only contribute to the formation of a memory but are also influenced by memories of previous experiences (e.g., through the generation of expectations that affect where we look or how we interpret a stimulus). In other words, our experience of previous events influences how we perceive and comprehend later ones. As we'll see, this is only one of the ways that the process of creating and using memories is dynamic in nature. However, we'll first cover a few important terms that are commonly used in research on memory.

Basic terms. Memory researchers typically think about the process of creating and remembering memories as following three general stages—*encoding, storage*, and *retrieval*. As discussed earlier, as events unfold, we try to make sense of them using both perceptual and reflective (elaborative) processes. Encoding describes the creation of a memory, as the information produced by these processes is translated into a format in which it can be stored in the brain. This representation is often referred to as a memory *trace*. Storage describes the period during which the representation is retained. During this period, memory traces are initially relatively fragile (this stage usually lasts for a few hours) but gradually are physiologically stabilized through a process of protein synthesis (e.g., see McGaugh, 2000). This stabilization process is called *consolidation*, and memories in this state are more resistant to disruption. Recently, researchers have discovered that even memories that are consolidated can be made unstable again by reactivating the memory (e.g., Nader et al., 2000). This process is called *reconsolidation*, and this appears to be one way that memories can be altered after being stored. The final phase, retrieval, describes the process of bringing back information stored in memory. Retrieval is often discussed using a spatial metaphor; people are described as searching for a particular memory. Most theories of memory assume that this search is cue-dependent. Cues can be conceived as internally or externally derived information that can be used to constrain the search process. For example, if you are trying to remember what you had for lunch yesterday, you might start by trying to remember where you had lunch. Remembering the location could help prompt your memory for what you ate and reduce the extent to which memories of other lunches come to mind. More broadly, the more closely the cues approximate the original experience, the more likely the memory will be retrieved (the *encoding specificity principle*; e.g., Tulving & Thomson, 1971). This has implications for interpreting performance on a given memory test as an index of memory. If someone fails to remember an item on a test, it does not necessarily mean that this information is not stored in memory. Rather, someone may simply not have sufficiently effective cues to retrieve it at that point in time. Researchers distinguish between *availability* (information is stored in memory) and *accessibility* (information can be retrieved at this particular moment) to make just this point (e.g., Tulving, 1983).

Memory as a constructive activity. If you stopped a person on the street and asked them how memory works, more than likely he or she would respond that memory is like a video recorder or a computer (e.g., Simons & Chabris, 2011). Researchers often refer to this notion of memory as

reproduction. In this view, events are experienced, stored, and later brought back as they had occurred. Indeed, sometimes memory feels as if we are simply reexperiencing what happened previously (e.g., Tulving, 1983). Like many metaphors, it has some elements of truth (see basic terms discussed earlier) but is also incorrect in a number of important ways. To begin, let's compare just a few features of a video camera recording with human memory (see table I.1). First, as long as the camera is pointed toward an object and it is in view, that object is going to be recorded. This is not the case with human beings. A person can have their eyes directed toward an object, yet their attention can be directed somewhere else (e.g., on their thoughts). For instance, research has found that people can miss dramatic changes to the environment (e.g., the person they're talking with changes or objects change) if their attention is directed elsewhere (change blindness; for a review, see Simons & Rensink, 2005). Because attention influences whether or to what degree information is represented in memory, human memory is selective in ways that mechanical recorders are not. Second, the cognitive processes involved in memory are influenced by a person's physiological state (e.g., stress; Wolf, 2009) and the affective (emotional) properties of objects in the environment (e.g., Kensinger, 2009a), but no similar factors influence the quality of video recordings. Third, video recordings play back "word for word" the event that was initially recorded. Human memory is not verbatim; people often remember selectively what they experienced and may only remember the gist of what happened. As we discuss in much more detail later, human memory can also be in error, for example, by including details that were not initially experienced (e.g., Zaragoza & Lane, 1994). Fourth, when a video is recorded, your ability to play back that recording is not affected by other recordings elsewhere on the tape or hard drive. Yet, the ability to remember information in human memory is affected by the similarity of other memories. Researchers use the term *interference* to describe this situation. For example, when information you've learned recently (e.g., the Spanish word for *dog*) impairs your ability to remember previous related information you learned (e.g., the French word for dog), this is called *retroactive interference* (e.g., Melton & Irwin, 1940). When information you have learned previously impairs your ability to remember information learned subsequently, this is called *proactive interference*. Finally, let's say that we play back a video in an environment that is very different from the environment in which it was recorded. This should have absolutely no effect on whether we can watch the recording. But, differences in environment or context do make a difference for human memory (e.g., Smith, 1979). For example, people can sometimes remember information in one context but not another (e.g., Tulving & Thomson, 1971).

If human memory is not reproductive, how can we characterize it? The consensus view of researchers is that memory is *constructive* in nature (e.g., F. Bartlett, 1932; Neisser, 1967; Tulving, 1983). This is true from our very first perceptions of an event, which are inferences based on ambiguous sensory information from the environment (e.g., Helmholtz, 1867; Kersten et al., 2004). Furthermore, as discussed previously, an encoded memory trace is not a literal reproduction of reality but is selective, and includes elaborative activity such as what an individual was thinking and feeling at the time. Retrieval is no less (re)constructive. Our recollections are pieced together based on information provided in the memory cue (including the retrieval environment), what we selectively access from the memory trace, as well as inferences we make about this information based on other knowledge we possess (M. K. Johnson et al., 1993; Neisser, 1967; Tulving, 1983). Neisser (1967) likened this process to that of a paleontologist trying to reconstruct a dinosaur skeleton from fossil remains—"out of a few stored chips, we remember a dinosaur" (p. 285). Thus, remembering is better seen as a process of pattern completion than one that simply involves activating a stored memory trace. This view highlights, for instance, how differently we may remember an event depending on the available retrieval cues (e.g., E. Loftus & Palmer, 1974; Ochsner et al., 1997). We discuss the implications of this view of memory later in the book, but

for now, it should be apparent that it conflicts with the view of memory commonly held by the public and the legal system.

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