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2.27 Episodic Memory: An Evolving Concept

K. K. Szpunar and K. B. McDermott, Washington University, St. Louis, MO, USA

2.27.1 Introduction

Although the term episodic memory did not exist until about 35 years ago, it captures much of what philosophers, psychologists, and lay people have meant by memory or remembering. Episodic memory – or the recollection of events from one's personal past – is therefore one of the most fundamentally important concepts in the study of human memory. It is the capacity for episodic memory that enables one to recollect the multitude of details surrounding one's most cherished moments.

A challenge inherent in writing a review chapter on episodic memory is that it is not a static term; the essence of the term episodic memory has morphed and broadened considerably over the short time of the term's existence. It should be no surprise, then, that different empirical evidence has been brought to bear on the different meanings. A further twist is that a single person, Endel Tulving, both introduced the term (in 1972) and has modified its meaning many times in the years since. As a result, his theorizing and adaptation of the concept has spawned much of the relevant literature, and this chapter draws very heavily upon his work and emergent ideas.

We have chosen the following approach in organizing this chapter. We begin by attempting to identify a few of the historical landmarks or prominent features proposed in the conceptual development of episodic memory. We then choose two topics to consider in some depth. Specifically, we consider evidence supporting the proposition that episodic memory is a distinct memory system, different from other types of memory. We then consider research bearing on the suggestion that episodic memory may represent only one facet of a more general cognitive capacity that enables mental time travel into both the subjective past and future.

2.27.2 Historical Landmarks

2.27.2.1 A Taxonomic Distinction: Episodic and Semantic Memory

The concept of episodic memory was formally introduced in a seminal chapter by Tulving (1972), who drew a distinction between memory for specific events (episodic memory) and memory for general knowledge and facts (semantic memory). For example, remembering that the word elephant had been present in a list of previously studied words, recounting the events surrounding the day of one's college graduation, or reminiscing about the most recent Christmas dinner with a family member would be considered instances of episodic memory. Knowing that elephants live in Africa, the name of the college one attended, and that a family gathering typically implies a special occasion would be classified as examples of semantic memory (*See* Chapter 2.28).

In 1972, Tulving explained that laboratory studies of human memory had long been concerned with episodic memory. That is, most experiments were of the same general design: Present events for study and then measure how well they are remembered at a later time. At this time, episodic memory was associated with a certain type of task: Those that required recall or recognition of a prior episode.

Although episodic and semantic memory are both declarative (i.e., may be articulated) and can be differentiated from memory that cannot be expressed in terms of representational information (i.e., procedural memory, or memory of how to perform a skill, see Squire, 1987), there exists a fundamental and straightforward distinction between episodic and semantic memory: Episodic memory involves remembering an episode from one's past that is specific to time and place, whereas semantic memory involves general knowledge that is not associated with specific episodes.

Tulving summarized his seminal 1972 chapter as having made "a case for the possible heuristic usefulness of a taxonomic distinction between episodic and semantic memory and two parallel and partially overlapping information processing systems" (Tulving, 1972: p. 401). At the time, the episodic/semantic distinction was offered as a proposal that the two types of memory may be separable. As will be seen, the concept of episodic memory quickly grew to denote more than its originally intended meaning. The taxonomic distinction between episodic and semantic memory, however, is a central feature of the original conceptualization that has stood the test of time. Indeed, this distinction has been adopted by the field and is in widespread use.

Before proceeding further, it is worth considering the similarities and differences between the term episodic memory and a few other, related terms. Autobiographical memory refers to personal memories of one's own life. These can be of two types: episodic or semantic. Consider the following examples: Remembering the first day of grammar school would rely upon episodic memory, whereas knowing the name of one's grammar school relies upon semantic memory. Both examples, however, represent autobiographical (self-related) memory. We should acknowledge, though, that researchers define autobiographical memory in different ways, so not all would agree with this classification scheme. Explicit memory is another term related to episodic memory. Explicit memory is a term often used as a heuristic for the type of memory used on an explicit test of memory; an explicit test is one in which a person is asked to willfully attempt to retrieve the past. Explicit memory can be contrasted with implicit memory, which is the unintentional manifestation of memory (e.g., if you were to read this chapter a second time, it would likely be read faster).

2.27.2.2 Subjective Awareness

The role of subjective awareness in memory has long been a topic of interest for the field (e.g., feeling-of-knowing judgments, tip-of-the-tongue states; for a historical review see Metcalfe, 2000). In 1983, Tulving published *Elements of Episodic Memory*, in which he explicitly applied such ideas to his own work. In that volume, Tulving proposed that memories for personal episodes are characterized by a strong feeling of re-experiencing the past. In contrast, Tulving argued that retrieval of general knowledge from semantic memory lacked this phenomenological quality. That is, although someone may know a fact (e.g., that St. Louis is the site of a famous arch) and is aware that he or she acquired knowledge of this fact in the past, one does so in a way that does not necessitate re-experiencing the instance in which the fact had been learned.

Tulving further argued that the feeling of re-experiencing a previously encountered event is the *sine qua non* of episodic memory. He outlined a general framework (General Abstract Processing System, or GAPS; **Figure 1**) by which to understand the act of remembering from episodic memory (Tulving, 1983). The GAPS framework was intended to highlight many issues associated with retrieval from episodic memory. We focus here on how this framework predicts the emergence of subjective awareness (or recollective experience, as it was referred to in 1983). As can be seen in **Figure 1**, an encoded event is converted into a latent memory trace (or engram;

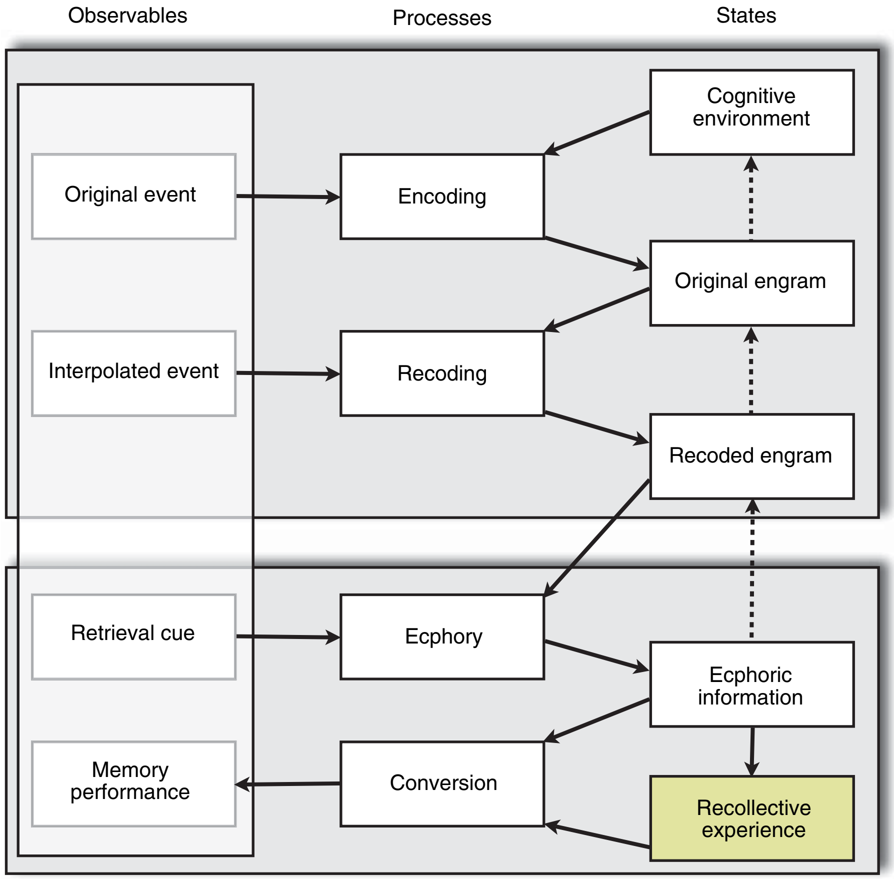

Figure 1 General Abstract Processing System: A conceptual framework for understanding retrieval from episodic memory. Adapted from Tulving E (1983) *Elements of Episodic Memory.* New York: Oxford University Press.

Semon, 1904). However, it is unlikely that the event will be remembered exactly as it had originally occurred. For instance, the latent engram related to that event is subject to recoding (e.g., by virtue of related interpolated events). The recoded engram then interacts with a retrieval cue to produce ecphory: The evocation of information from a latent engram into an active state (Semon, 1904; Tulving and Madigan, 1970; Tulving, 1976; Schacter et al., 1978). That is, the synergistic product of the memory trace and the retrieval cue determine the nature of what is remembered (ecphoric information; *See* Chapter 2.16; Tulving, 1982), which in turn determines recollective experience. Accordingly, the rememberer will become aware of the encoded event to the extent that ecphoric information is representative of the original episode. At this time, no data were presented that directly assessed a participant's recollective experience for the contents of his or her memory.

On the basis of the notable absence of phenomenological data from the majority of verbal learning experiments (but see Metcalfe, 2000, who discusses various exceptions), Tulving (1983) suggested that students of psychology had not yet begun the study of episodic memory. Of course, this claim directly contradicts his previous (Tulving, 1972) assertion, which he declared in 1983 to have been "not very well thought out" (Tulving, 1983: p. 9). Prior research had assumed a correlation between a learner's behavioral response and subjective awareness. That is, if a learner was able to recall or recognize having previously encountered a given stimulus item (e.g., a word from a previously presented list) it was assumed that he or she mentally re-experienced the original event. It is now well-established that there is no direct correlation between behavior on a memory test and the cognitive processes underlying that behavior (Schacter, 1987; Tulving, 1989a; Jacoby, 1991; Roediger and McDermott, 1993; Toth, 2000; *See*

Chapter 2.33). Tulving (2002b) reflected on this issue by pointing out that episodic memory is concerned with what happened where and when. Typical verbal learning experiments assessed the what aspect but left when and where unqueried.

With this problem in mind, Tulving (1985b) devised a research paradigm designed to illustrate that a learner in a memory experiment does not necessarily remember the instance in which he or she experienced an event that he or she knows occurred in the past. This procedure was a starting point for exploring the nature of subjective awareness.

2.27.2.3 The Remember/Know Paradigm

The remember/know paradigm was introduced as a tool for investigating a learner's subjective awareness of a prior study episode (Tulving, 1985b), although current procedures have been modified somewhat from the original implementation (see Rajaram, 1993). For the most part, a remember/know experiment takes the form of the typical laboratory memory experiment. Learners study a set of stimulus materials at time one (e.g., a list of words) and take a memory test on those materials at time two. The innovation that Tulving introduced was to ask learners at the time of the memory test whether they actually remembered the exact prior occurrence of a given study item (e.g., the word ocean), or whether they just knew that the item had been presented, but could not remember the precise instance of its original presentation (Tulving, 1985b; Gardiner, 1988; Rajaram, 1993; Gardiner and Richardson-Klavehn, 2000; *See* Chapter 2.17).

Tulving (1985b) showed that learners could easily make these mental distinctions and that both remember and know responses were present during tasks that previously had been thought to tap episodic memory (i.e., recognition, cued recall, and even free recall). This important finding suggested that learners had two routes by which to recover the contents of a past study episode. Remembering was identified as the hallmark of episodic memory and was further associated with a unique mental state called autonoetic (self-knowing) awareness, implying a feeling of personally re-experiencing the past. Knowing was associated with semantic memory and noetic (knowing) awareness, a mental state lacking the feeling of personally re-experiencing the past. Further, memory tasks were found to vary in the degree to which they relied upon remembering, with free recall demonstrating the greatest level of remember responses (i.e., the greatest reliance on episodic memory). Hence, an important conclusion here is that no memory test is a pure measure of episodic memory, and tests designed to assess episodic memory differ in the degree to which they rely on the construct, with none achieving a pure assessment of episodic memory.

It is interesting to note that the subjective (autonoetic) awareness that Tulving had identified as a central component of episodic memory was similar to what pioneers of memory research had in mind when discussing remembering. For instance, William James (1890) wrote of remembering as, "a direct feeling; its object is suffused with a warmth and intimacy to which no object of mere conception ever attains" (James, 1890: p. 239). Hermann Ebbinghaus, (1885) adopted a generally understood conceptualization of memory that had been put forth by John Locke, defining remembering as the emergence of a sought after mental image that is "immediately recognized as something formerly experienced" (Ebbinghaus, 1885: p. 1). According to Locke, memory was the power of the mind "to revive perceptions, which it has once had, with this additional perception annexed to them, that it has had them before" (Locke, 1975: p. 150).

2.27.2.4 Retrieval Mode

Aside from the subjective awareness (or lack thereof) thought to accompany memory retrieval, Tulving (1983) outlined various other features by which he distinguished episodic from semantic memory (see also Tulving, 2005). At the time, the listing of differences was meant as a starting point for discussion, rather then any acknowledgment of hard-set facts. Importantly, the features on which episodic and semantic memory were hypothesized to differ were divided into three categories, each separately focusing on the information handled by episodic and semantic memory, their operations, and their applications. The main point of these subcategories was to emphasize that the distinction between episodic and semantic memory was more than just a difference in the type of information under consideration.

For instance, Tulving (1983) made a distinction regarding the manner in which access is gained to episodic and semantic knowledge. According to Tulving, access to information from episodic memory is deliberate and requires conscious effort. Conversely, semantic knowledge may be accessed in a relatively automatic fashion. For instance, stimuli in the environment are immediately interpreted on the basis of semantic knowledge. When reading a novel, the meanings of words come to mind with relative ease. However, it is only when one is in a particular state of mind that is focused on their personal past that the same stimulus may remind one of a particular episode. For example, single words have been shown to act as effective cues for the retrieval of personal autobiographical memories (Crovitz and Schiffman, 1974; Robinson, 1976); this is only the case, however, when participants are specifically instructed to use those words as retrieval cues. This state in which one focuses attention on their past and uses incoming information as cues for past experiences is referred to as retrieval mode (Tulving, 1983; Lepage et al., 2000). A potential exception to this rule involves spontaneous conscious recollection, wherein personal memories suddenly come to mind. One common example is the evocation of an emotional memory (e.g., one's first kiss) by a particular piece of music (see Berntsen, 1996, 1998). Similar examples have been offered in the prospective memory literature (McDaniel and Einstein, 2000; Einstein et al., 2005).

Tulving (1983) argued that retrieval mode constituted a necessary condition for retrieval from episodic memory but admitted, "we know next to nothing" about it (Tulving, 1983: p. 169). In terms of the behavioral literature on the topic, the same statement holds true today. Although subsequent research on the topic has illuminated the nature in which the presence/absence of retrieval mode may be manipulated in the context of a memory experiment (e.g., retrieval intentionality criterion, Schacter et al., 1989), we have not learned much more about the state itself.

Recent advances in neuroimaging techniques (see section titled "Functional neuroimaging") have revived interest in the study of retrieval mode. For example, Lepage et al. (2000) suggested that brain regions showing similar patterns of brain activity during either successful or failed attempts of episodic retrieval (relative to a control task that does not engage episodic retrieval processes) can be taken as neuroanatomical correlates of retrieval mode. Reviewing the relevant literature, Lepage et al. identified six frontal lobe regions (mostly right lateralized) that appear to become active whenever participants attempt to retrieve past information, regardless of whether they are successful or not. Thus, the underlying nature of retrieval mode has not yet been delineated, but neuroimaging techniques may prove useful in approaching this issue.

2.27.2.5 Subjective Awareness, Self, and Time

As we have mentioned, the concept of episodic memory has been considerably refined over the years. According to Tulving's most recent conceptualization, episodic memory is a recently evolved, late-developing, and early-deteriorating past-oriented memory system, more vulnerable than other memory systems to neuronal dysfunction, and probably unique to humans. It makes possible mental time travel through subjective time, from the present to the past, thus allowing one to re-experience, through autonoetic awareness, one's own previous experiences (Tulving, 2002b: p. 5).

Thus far we have highlighted subjective (autonoetic) awareness as the defining feature of retrieval from episodic memory. Equally important are concepts of self and subjective time (Tulving, 2002a,b). That is, episodic memory requires the capacity to represent a psychologically coherent self that persists through subjective time, whose past experiences are recognized as belonging to the present self (self-contiguity; Klein, 2001). Klein (2001; see also Klein et al., 2004) argues that a breakdown of self-contiguity disrupts the ability to represent past and present mental states as being aspects of the same personal identity, thus leaving an individual incapable of identifying a current mental state as one that was previously experienced. Klein (2001) reviews compelling evidence to support this claim. For example, individuals with schizophrenia – a population characterized by impairments in self-contiguity – have profound deficits in episodic memory (McKenna et al., 1994).

2.27.2.6 The Episodic Memory System

As can be seen by the 2002 definition (quoted in the previous section), episodic memory grew to encompass much more than the type of memory that allowed one to recall or recognize prior events. It became a hypothetical neurocognitive memory system that is characterized, relative to other memory systems, by its unique function and properties (Tulving, 1984, 1985a; Sherry and Schacter, 1987; Schacter and Tulving, 1994). Of course, this basic idea was foreshadowed somewhat by the earlier description (even in the 1972 description regarding partially overlapping processing systems), but the earlier emphasis had been on the basic taxonomic distinction and not on the much more bold claim that it is a memory system.

What exactly is a memory system, and what might the criteria be for establishing one? These questions have spurred a great deal of controversy, much of which appeared in the context of the emerging literature on implicit memory in the late 1980s and early 1990s (Tulving, 1985a; Sherry and Schacter, 1987; Roediger et al., 1990, 1999; Schacter and Tulving, 1994; Buckner, 2007). Some theorists were concerned that the lack of stringent criteria would lead to a proliferation of putative memory systems, many of which were probably not well justified. We wish to sidestep that general debate here; our view is that although the criteria for establishing a memory system are not well-specified (and are often not met even when specified), there is nonetheless strong evidence that episodic memory represents a fundamentally different kind of memory than semantic memory and that the hypothesis that it is indeed a distinct memory system is certainly viable. Here we choose to focus on what was meant by this claim that episodic memory should be considered a memory system and review some of the evidence bearing on the claim.

First, the episodic memory system enables its owner to process (i.e., encode, store, and retrieve) personally experienced episodes. In this way, it allows one to accomplish a feat not possible without the system. Secondly, episodic memory can be differentiated from semantic memory on a variety of dimensions (Tulving, 1972, 1983). We have already addressed one of these dimensions at length, namely the conscious awareness that characterizes episodic (autonoetic awareness) relative to semantic (noetic awareness) memory. Hence, episodic memory has a set of properties that differentiate it from other systems.

It is important to note that the episodic memory system is hypothesized to be related to and have evolved from phylogenetically earlier systems, including semantic memory (Tulving, 1985b, 1995). That is, the ability to consciously re-experience a specific event from the past may have grown out of a more general ability to use the past in an informative fashion, albeit one lacking a sense of subjectively reliving the event (see **Figure 2**). The episodic memory system "depends upon but goes beyond the capabilities of the semantic system. It could not operate in the absence of the semantic system" (Tulving, 1989b: p. 362). Of course, the evolutionary relation between episodic memory and semantic memory is not subject to

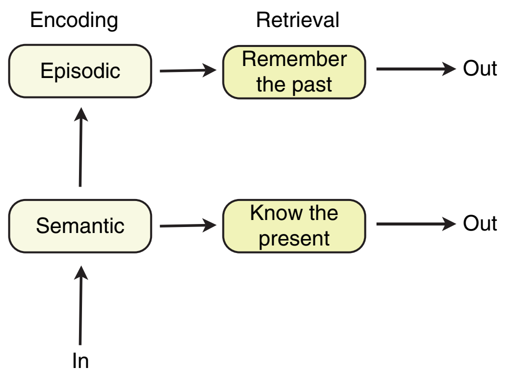

Figure 2 Sketch of the relations between semantic and episodic memory. Information can be encoded into semantic memory independent of episodic memory but must be encoded into episodic memory through semantic memory. Encoded and stored information is potentially available for retrieval from one of the two systems or from both of them. Adapted from Tulving and Markowitsch (1998).

laboratory investigation. As will be seen, a similar relation appears to exist in the course of ontogenetic development, though, whereby episodic memory emerges in the presence of fully functioning semantic memory.

In the following section, we present evidence from neuropsychology, functional brain imaging, and developmental psychology consistent with the idea that episodic memory may in fact represent a viable neurocognitive system or is at least functionally dissociable from semantic memory.

2.27.3 Converging Evidence for the Episodic Memory System

The idea that episodic memory might represent a distinct memory system emerged largely out of the behavioral psychological literature, where it was shown that a particular independent variable might affect performance on one measure or set of measures (e.g., measures thought to draw largely upon episodic memory) but not affect performance (or affect performance in the opposite direction) on different measures, thought to draw largely on semantic memory. For example, level of processing during encoding affects the likelihood of later remembering but not knowing (when the remember/know paradigm is used; see Yonelinas, 2002, for review). Perhaps the most compelling evidence for the idea comes from brain-based studies, particularly neuropsychological studies. Here it can be shown that some patients lose the ability to use episodic memory while retaining other classes of memory, including semantic memory. Following, we review some of this evidence.

2.27.3.1 Neuropsychology

Neuropsychological observations of brain-damaged individuals have contributed a great deal to our understanding of the organization of human memory in the brain. Perhaps the most famous contribution is that of Scoville and Milner (1957), who reported the case of patient HM. HM incurred dense amnesia following a bilateral resection of the medial temporal lobes. Since then, a great deal of converging evidence from neuropsychological observations of human patients, neurological experimentation using animal subjects, and more recent advances in functional brain imaging techniques has corroborated Scoville and Milner's original observation: The medial temporal lobes play an important role for memory (for an early reference, see Bekhterev, 1900).

Of particular interest, Scoville and Milner (1957) classified the impairment observed in patient HM as one of declarative memory. That is, no distinction was made between episodic and semantic memory. Of course, this is not surprising given that the distinction was not introduced to the neuropsychological community for another 30 years (Tulving, 1985b; although see Nielsen, 1958, for a foreshadowing of the distinction). Another potential reason the distinction was not made is because it was not readily apparent. HM's surgical resection encompassed large portions of the medial temporal lobes, including, but not limited to, the hippocampal formation. It has recently been considered that hippocampal damage is particularly associated with deficits of episodic memory, whereas semantic memory problems arise as a result of adjacent cortical damage (Mishkin et al., 1997; Aggleton and Brown, 1999). Accordingly, both episodic and semantic memory may have been damaged in patient HM.

Vargha-Khadem and her colleagues have recently reported on a set of three amnesic patients, each of whom sustained bilateral pathology restricted to the hippocampus following an anoxic episode in early life (ranging from birth to 9 years; Vargha-Khadem et al., 1997). Unlike most amnesic patients, their ability to acquire knowledge remains intact. As a result, all three patients have been able to progress through the educational system with little trouble. However, all three are severely impaired in their ability to recall events, even those that occurred minutes previously. These cases represent a clear dissociation between episodic and semantic memory function in the presence of brain damage restricted to the hippocampus.

Although dissociations between episodic and semantic memory are rarely clear-cut, there do exist many case reports in which one is relatively more impaired than the other. Most such cases have reported greater deficits of episodic memory relative to semantic memory (e.g., Cermak and O'Connor, 1983; Calabrese et al., 1996; Kitchener et al., 1998; Levine et al., 1998; Viskontas et al., 2000), although the reverse pattern also occurs (e.g., Grossi et al., 1988; De Renzi et al., 1997; Yasuda et al., 1997; Markowitsch et al., 1999). The reversed pattern (i.e., greater impairment of semantic than episodic memory) is not well accommodated by the idea that episodic memory requires semantic memory to operate.

It is important to note that these case studies are characterized by various etiological factors and resulting patterns of brain impairment that are not restricted to the medial temporal lobes. In general, there is good reason to believe that the operations of various memory systems (including episodic and semantic) depend upon highly distributed and interacting regions of the brain (Mesulam, 1990; Nyberg et al., 2000). For instance, although the role of hippocampus is well established, deficits of episodic memory are also highly correlated with frontal lobe pathology (e.g., Ackerley and Benton, 1947; Freeman and Watts, 1950; Stuss and Benson, 1986; Wheeler et al., 1997).

As an example of relative impairment of episodic memory, consider patient ML (Levine et al., 1998). Following a severe closed-head injury, patient ML became amnesic for pretraumatic events. Although ML retained the capacity to recount many autobiographical facts, he was unable to re-experience any specific event associated with them. For instance, ML could recount the name of a high school teacher perfectly well but was unable to recollect any experience associated with that individual. In brief, the episodic component of patient ML's autobiographical memory was missing. His pathology was restricted to right ventral frontal lobe, including the unicinate fasciculus, a band of fibers connecting frontal and temporal cortices. Patient ML is one of many brain-damaged patients who have lost much of their episodic and semantic memory, with no accompanying anterograde (posttrauma) amnesia.

That is, these patients are able to learn new information. With respect to these patients' retrograde (pretrauma) memory problems, semantic memory typically recovers, while episodic memory remains largely impaired.

As an example of disproportionate impairment of semantic memory, consider the report by Grossi et al. (1988) of a student who lost her ability to reproduce factual knowledge that she had learned prior to her injury. For instance, she was unable to recount various facts learned in school, although she could remember specific meetings with instructors. Summarizing over many such observations, Kapur (1999) concluded that, "loss of factual, semantic memories is readily dissociable from loss of memory for personally experienced events" (p. 819).

Perhaps the most well-documented example of a dissociation between episodic and semantic memory is a patient known as KC, who has been investigated by Tulving (1985b) and his colleagues at the University of Toronto. At the age of 30, patient KC sustained damage to several regions of his brain (including the medial temporal lobes) following a closed-head injury from a motorcycle accident (Rosenbaum et al., 2000, 2005). As with many amnesic patients, neuropsychological testing revealed that KC had retained many of his cognitive capacities. For instance, his intelligence and language faculties remain largely unaffected; he can read and write; he is able to focus and pay close attention to a conversation; he is capable of performing a wide variety of mental tasks, including visual imagery; and his short-term memory is normal.

KC also knows many details about his personal past. Among other things, he knows the names of many of the schools that he attended, the address of his childhood home, the make and color of his former car, and the location of his family's summer home. That is, KC's semantic knowledge of information acquired prior to the brain trauma remains largely intact. Nonetheless, KC cannot remember a single personal episode associated with this knowledge. For instance, although he can readily describe the process of changing a flat tire, he cannot remember ever having performed this task. In fact, KC cannot remember a single episode from his lifetime. This lack of episodic memory extends to highly emotional events; KC has no recollection regarding the untimely death of his brother or a bar fight that left him with a broken arm.

Given the diffuse nature of KC's brain pathology, it remains unclear what the precise cause of the clear dissociation between episodic and semantic memory might be, although strong arguments can be made regarding damage to regions of KC's medial temporal lobes (e.g., Vargha-Khadem et al., 1997; Klein et al., 2002) and frontal cortex (see Wheeler et al., 1997). Regardless, the story of patient KC is a remarkable one and suggests that there may emerge a biological dissociation between episodic and semantic memory.

As a whole, these studies show that various forms of deficits can be found with respect to episodic and semantic memory. Note, however, that there has not yet been successful resolution of how the current concept of episodic memory could accommodate finding a properly functioning episodic memory system occurring in a person with semantic memory deficits. Nonetheless, the more general finding that episodic and semantic memory can be dissociated not just as a function of independent variables but also in neuropsychological patients is consistent with the idea that episodic memory should be considered a memory system.

2.27.3.2 Functional Neuroimaging

There now exist seemingly countless neuroimaging studies of episodic memory. Here we identify a few general patterns that indicate a brain-based dissociation between episodic and semantic memory. We have found it necessary to be brief, and we suggest that the interested reader seek some of the in-depth reviews that detail the wealth of studies that have shaped our understanding of episodic memory and how it is represented in the brain.

Traditional psychological studies and (especially) lesion studies do not allow the easy separation of retrieval from storage. In neuroimaging studies, however, retrieval effects can arguably be better isolated. Here we focus primarily on retrieval from episodic memory for a couple reasons. First, the encoding of information into episodic memory seems to rely largely upon retrieval of information from semantic memory (Tulving et al., 1994; see also Prince et al., 2007). Storage is a phase not well studied with the methods under consideration here. Finally, retrieval has been argued to be the foundation for understanding memory; indeed, Roediger (2000) entitled a chapter "Why retrieval is the key process in understanding human memory."

Functional neuroimaging techniques, such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), allow neuroscientists to examine the healthy human brain at work.

When participants engage in a given cognitive task, PET or fMRI provide information about the level of cerebral blood flow (PET) or blood oxygenation level (fMRI) localized in the brain regions recruited for the task. Such metabolic changes correlate highly with underlying neuronal activity and thus provide important insights into the brain structures that might underlie specific cognitive tasks.

One challenge in conducting brain-imaging research lies in experimental design. In the typical design, metabolic changes associated with two cognitive tasks are contrasted with one another in hopes of isolating the neural correlates of the cognitive process of interest. Researchers attempt to contrast a pair (or in some cases a set) of tasks that are highly similar to one another but that vary on one key dimension. Note that such a contrast highlights differences between tasks but (in the absence of a third, low-level baseline task) is unable to address areas of common activation.

For instance, in order to identify the neural correlates associated with retrieval from episodic memory, studies have contrasted a task that draws upon episodic memory with a second retrieval task that does not involve the reinstatement of specific spatial-temporal details (e.g., retrieval of general knowledge, which draws upon semantic memory). Although one may be certain that one task reasonably depends more on episodic memory and the other more on semantic memory, neither task is a direct window into the type of memory it is designed to reflect; confidence is gained, however, when results replicate across studies and tasks. This approach makes testable the assumption made by Tulving that retrieval from episodic memory relies upon semantic memory but adds to it certain other processes or brain regions. It is therefore possible to see whether episodic memory seems to rely upon the same brain regions as semantic memory with the addition of others.

With the neuropsychological studies just reviewed in mind, one could make some predictions with respect to how episodic and semantic memory might differ. Relative to some lower-level baseline task, semantic and episodic memory would be expected to reveal very similar activity. To the extent that episodic memory indeed builds upon semantic memory, any differences seen would be expected to be in the direction of greater activity for episodic than semantic memory. Specifically, retrieval from episodic memory would be expected to rely more upon hippocampus (and potentially surrounding structures) than would semantic memory.

In general, neuroimaging studies of episodic memory do not line up perfectly with the neuropsychological studies, and the precise reasons behind this situation are still unclear (Buckner and Tulving, 1995). One way in which the data are consistent with the theory is that in general, activation for retrieval from semantic and episodic memory tasks is very similar, with many (but certainly not all) differences tending to go in the direction of episodic retrieval. One puzzling finding is that the hippocampus is not reliably seen as particularly active during retrieval from episodic memory, especially as typically studied, with verbal materials (Fletcher et al., 1997; Schacter and Wagner, 1999). However, neuroimaging studies of episodic memory using autobiographical memories as the content of retrieval, rather than word lists learned in the laboratory, do overlap nicely with lesion studies (e.g., hippocampal activity is commonly reported in neuroimaging studies of autobiographical memory retrieval). Thus, questions regarding the differences obtained using differing methodologies may ultimately need to focus on the tasks being used in conjunction with the method of inquiry.

Direct comparisons of tasks designed to rely on episodic and semantic memory have not been reported as often as one might think (but for some examples see Shallice et al., 1994; Fletcher et al., 1995; Nyberg et al., 1996; McDermott et al., 1999a,b). Those who have done so show that regions within frontal cortex are more active for episodic than semantic memory. In the early 1990s (when the literature was based largely on PET methodology), retrieval-related activation in frontal cortex was almost always right-lateralized in or near Brodmann Area (BA) 10 (for a review see Buckner, 1996); more recent studies using fMRI tend to show bilateral or left-lateralized activity here. Following this relatively unanticipated finding, much work has been devoted to attempting to identify the processing underlying these prefrontal regions involved in episodic retrieval. Some hypotheses regarding the processes include retrieval mode (the mental set of attempting to retrieve the past, LePage et al., 2000), retrieval success (McDermott et al., 2000), postretrieval processing (a set of processes following the initial recovery of information in the retrieval phase; see Rugg and Wilding, 2000), or the amount of retrieval effort extended (Schacter et al., 1996). Different regions certainly contribute to different processes, but it is not yet clear which regions are contributing which processes (or even if the correct processes have been identified). A precise understanding of the situation awaits further work.

Another somewhat surprising finding is the role parietal cortex appears to play in episodic memory. Contrasts of episodic memory tasks with semantic memory tasks tend to activate regions within bilateral inferior parietal cortex (within BA 40) and within medial parietal cortex (precuneus and posterior cingulate/retrosplenial cortex, e.g., McDermott et al., 1999b), and contrasts of episodic retrieval with other comparison tasks have elicited similar findings, which have led to recent attempts to identify the role of parietal cortex in memory (Shannon and Buckner, 2004; Wagner et al., 2005). Although the possible importance of parietal cortex in episodic retrieval was at the time unanticipated from the lesion literature, a closer look at the lesion literature shows that lesions on medial parietal structures can indeed produce what has been called retrosplenial amnesia (Valenstein et al., 1987).

Of historical importance is an early generalization in functional imaging studies of human memory, which suggested an apparent asymmetry between episodic encoding and retrieval processes: Hemispheric Encoding/Retrieval Asymmetry (HERA; Tulving et al., 1994). In general, episodic encoding was thought to be more strongly associated with left frontal lobe activity (than right), whereas episodic retrieval was more strongly associated with right frontal lobe activity (than left). Because episodic encoding is believed to involve a high degree of semantic elaboration of incoming information, semantic retrieval has also been associated with left frontal lobe activity. As reviewed above, most researchers would probably argue that the more profitable approach is to attempt the ascription of processes to specific cortical regions (rather than making broad generalizations to larger regions of cortex, e.g., the role of the right frontal lobe). Nonetheless, the HERA idea was influential in the late 1990s and served as a guiding framework for a number of studies.

In this short review, we have necessarily omitted many relevant issues from consideration. Among those are fMRI studies of remembering and knowing (e.g., Henson et al., 1999; Eldridge et al., 2000; Wheeler and Buckner, 2004) and studies from the tradition of autobiographical memory (see Maguire, 2001 for review). Further, event-related potential (ERP) studies anticipated the importance of parietal cortex in retrieval (Rugg and Allan, 2000) and some of the differences seen in remembering and knowing.

To summarize, initial contrasts of episodic and semantic memory were expected to elucidate the role of the hippocampus in episodic memory. Although some studies showed such activation, many did not. Attention then turned to the role of frontal cortex in remembering (with an accompanying new look at the neuropsychological literature). Most recently, the role of parietal cortex has become of great interest. The questions being asked are essentially of the flavor of which regions contribute which processes. In our view, this approach is the best one to take at this point (see, too, Roediger et al., 1999). Neuroimaging studies have not well adjudicated the question of whether episodic memory is a memory system but have clarified thinking with respect to how (in process terms) episodic and semantic memory differ and what the neural substrates of those different processes might be. Note that this review has focused on studies that are somewhat relevant to the question of whether episodic memory can be thought of as a memory system dissociable from semantic memory; other related issues (e.g., a comparison between remembering and knowing or between successful and unsuccessful retrieval attempts) have not been addressed, as we see them as less critical to the question under consideration here (although they address fundamentally important issues in the topic of remembering).

2.27.3.3 Development of Episodic Memory: The Magic Number 4 ± 1

Episodic memory is a late-developing memory system that emerges in the context of an already existing ability to draw upon the past in an informative fashion. Beginning at an early age, children are able to acquire vast amounts of knowledge from their surroundings. For instance, within the first few years of life, a child will have learned and retained the meanings of thousands of words and detailed knowledge pertaining to the identities of various objects in their environment. This early accumulation and utilization of knowledge is best characterized in terms of semantic memory. That is, although children know about many things that they have learned in the past, the capacity to reliably remember specific events does not emerge until approximately 4 years of age.

As with various other developmental milestones, episodic memory emerges in a gradual manner. Specifically, although most 3 year olds have great difficulty with tasks that are believed to require episodic memory, there do appear glimpses that this capacity is beginning to manifest itself. For instance, by the age of

3 years, many children are capable of reporting the content of an event that they had previously witnessed in the laboratory (Howe and Courage, 1993; Bauer et al., 1995; Bauer and Werenka, 1995). However, the descriptions are typically vague, and it is difficult to know whether these children remember the precise episodes they describe, or whether they just know about them.

Johnson and Wellman (1980) have presented data suggesting that the ability to discriminate between the mental states of remembering and knowing does not emerge until the age of 5 years. In their study, few 4 year olds, some 5 year olds, and most first-grade children demonstrated an understanding of the distinction. This finding is consistent with the claim that children under the age of 4 years are likely relying upon semantic memory when reporting on events from their past.

A great deal has been learned about the emergence of episodic memory through the use of source memory tests (Johnson and Raye, 1981; Johnson et al., 1993). Not only do such tests require the participant to remember the content of a prior study episode, but the participant must also remember the context (e.g., when, where, etc.) in which that content was learned. Source memory tasks are believed to be good tests of episodic memory in that a correct response requires the reinstatement of specific spatial–temporal aspects of the originally encoded event. Studies that have adapted the source memory paradigm for use with children are consistent in their findings: The capacity for episodic memory appears to emerge around the age of 4 years.

In a particularly clear demonstration, Gopnik and Graf (1988) had 3-, 4-, and 5-year-old children learn the contents of a drawer under one of three conditions. The children were told about the contents of the drawer, were allowed to see the contents of the drawer for themselves, or were given hints so they could infer the contents of the drawer. During a later test, the researchers were interested in the children's ability to answer two questions: What was in the drawer, and how do you know? With regard to the first question, retention of the contents of the drawer was comparable across all age groups. All children knew what they had seen. This was not the case when the children were required to discriminate the source of their knowledge. Although the 5-year-old children made few mistakes in describing the manner in which they had learned about the contents of the drawer, the 3 year olds performed at chance levels (see also Wimmer et al., 1988; O'Neill and Gopnik, 1991). That is, only the 5-year-old children remembered the circumstances under which they had seen the contents.

This basic finding has been replicated many times (e.g., Lindsay et al., 1991; Taylor et al., 1994; see Wheeler, 2000b; Drummery and Newcombe, 2002, for a review). In general, 3 year olds show initial signs of a developing episodic memory system, but for the most part they have great difficulty when they are required to report specific details of past occurrences. By the age of 5 years, most children appear to possess fully functioning episodic memory, although this capacity is likely to continue to develop thereafter (for related discussion, see Nelson, 1984; Gopnik and Slaughter, 1991; Flavell, 1993; Howe et al., 1994; Perner and Ruffman, 1995; Wheeler et al., 1997; Wheeler, 2000a,b; Tulving, 2005; Piolino et al., 2007). With respect to the purposes of our present discussion, children of all ages (except those younger than 8 months; Wheeler, 2000b) possess intact semantic memory, the context in which episodic memory develops.

2.27.4 Episodic Memory and Mental Time Travel

Finally, we consider the most recent conceptual development regarding episodic memory, namely, its relation to mental time travel. The idea, initially delineated by Tulving (1985a), is roughly that humans (and perhaps only humans) possess the ability to mentally represent their personal past and future (see also Suddendorf and Corballis, 1997; Tulving, 2002a). That is, just as we can vividly recollect our personal past, we can also, with a seemingly equal level of vividness and efficacy, mentally represent personal future scenarios (episodic future thought).

Beginning with the pioneering work of Hermann Ebbinghaus (see also Nipher, 1876), students of psychology and neuroscience have expended more than 100 years of thought and careful experimentation toward an understanding of human memory. However, there has been surprisingly little inquiry into episodic future thought. According to Tulving and his colleagues, both capacities represent an important component of autonoetic consciousness, which is the ability to "both mentally represent and become aware of subjective experiences in the past, present, and future" (Wheeler et al., 1997: p. 331).

Next, we review evidence suggesting that the capacity for episodic future thought (Atance and

O'Neill, 2001) is intricately related to the ability to vividly recollect one's past. Specifically, it has been argued that impairments to both capacities co-occur following brain damage (Tulving, 1985; Klein et al., 2002), that both share similar neural networks (Okuda et al., 2003; Addis et al., 2007; Szpunar et al., 2007), and that both appear rather late in ontogenetic development (Busby and Suddendorf, 2005).

2.27.4.1 Neuropsychology

For an example of selective damage, consider again patient KC. Along with a selective deficit of episodic memory, KC is unable to project himself mentally into the future. When asked to do either, he states that his mind is "blank"; when asked to compare the kinds of blankness in the two situations, he says it is the "same kind of blankness" (Tulving, 1985: p. 4).

A similar profile is exhibited by patient DB, studied by Klein and colleagues (Klein et al., 2002); DB experienced an anoxic episode following cardiac arrest and can no longer recollect his past, nor can he project himself into the future. Interestingly, Klein et al. revealed that DB was able to think about the past and future in a nonpersonal (semantic) manner. That is, while DB could not report any of what he had personally experienced in the past or any of what he might experience in the future, he could report general facts related to the past, along with what might generally occur in the future (e.g., concerns about global warming).

Hassabis et al. (2007) replicated and extended these findings in a more systematic fashion. In that study, the authors presented a set of five amnesic patients with brain damage localized to the hippocampal formation. Each of these patients is densely amnesic for personal episodes but retains intact semantic memory. To test whether the profound deficit of episodic memory was accompanied by a deficit in episodic future thought, the authors tested the patients' ability to form mental images of novel future experiences. Specifically, the patients were presented with a series of 10 cues and asked to imagine themselves in the context of either novel (e.g., castle) or familiar (e.g., possible event over next weekend) settings. Relative to those of control subjects, the patients' images were "fragmentary and lacking in coherence" (Hassabis et al., 2007: p. 1728).

The aforementioned case studies represent only a few of many reports about amnesic patients. Most other investigations into the phenomenon of amnesia have, for the most part, focused on the memory problems inherent in such patients. For instance, many others have been interested in investigating the relative effects of brain damage on episodic versus semantic memory (Kapur, 1999; Wheeler and McMillan, 2001). Thus, it remains uncertain whether comparable impairments in backward- and forward-going aspects of mental time travel are common in all such patients.

Nevertheless, there do exist prior reports describing amnesic patients as living in the permanent present (Barbizet, 1970; see also Lidz, 1942), and cases similar to the ones mentioned above have been reported (Stuss, 1991; Dalla Barba et al., 1997; Levine et al., 1998). In addition, there exist extensive reviews of case study reports on patients with frontal lobe damage (e.g., Luria and Homskya, 1964; Luria, 1969). One common characterization of these patients is that they seem to be detached from the past and unconcerned about matters related to their personal future (Ackerley and Benton, 1947; see also Freeman and Watts, 1950; Ingvar, 1985; Fuster, 1989; Wheeler et al., 1997; Wheeler, 2000a).

2.27.4.2 Functional Neuroimaging

The psychological study of episodic future thought has been attempted only sporadically (D'Argembeau and Van der Linden, 2004, 2006; Szpunar and McDermott, in press), and the search for its neural substrates has begun only very recently. Note that we draw an important distinction between episodic future thought and more general thoughts of the future, such as planning, which has received extensive attention in the literature and is thought to rely heavily on regions within frontal cortex (Stuss and Benson, 1986; Shallice, 1988; Fuster, 1989). The set of procedures under examination here – comprising episodic future thought – are arguably a necessary precursor to planning; without the ability to envision oneself spending a weekend with friends on the ski slopes, for example, it is unlikely that one would plan the weekend.

Consider a recent PET study by Okuda et al. (2003). Participants were asked to speak aloud for 1 min about their near future (the next few days), far future (next few years), near past (recent few days), and far past (last few years). Activity during these states was compared to each other and to a fifth, baseline state, which involved talking about the meaning of various words. Two regions in anteromedial frontal cortex and medial temporal cortex were more active for the future conditions than the past conditions; other regions (in nearby medial frontal and medial temporal cortex) exhibited the opposite effects (more activity for past conditions relative to future). The authors suggested that remembering the past and planning for the future likely share common neural correlates and that it may be necessary for past experiences to be reactivated in order to facilitate an effective plan for future events (see too Burgess et al., 2000). Their data suggest that specific regions within frontal and medial temporal cortex might be suited for these functions. Although quite interesting, these data are of questionable relevance to the topic under consideration because in speaking about the future, the participants in this study tended not to focus upon specific future episodes but instead spoke about intentions, conjectures, and schedules. In contrast, these aspects were not much present when speaking about the past (i.e., the past tended to focus on specific episodes). In the other two studies to be considered, participants were asked to focus on specific episodes (either episodes that might take place in the future or ones that indeed took place in the past).

Szpunar et al. (2007) used fMRI to identify brain regions that might be important for representing oneself in time and then to examine those regions to see whether or not they are similarly engaged by past and future thought. In order to accomplish this goal, participants were asked to perform a set of three tasks. In all of these tasks, participants viewed a series of event cues (e.g., birthday party) and were asked to envision a specific scenario in response to the cues. In one task, the instructions were to recollect a personal memory of that kind of event (e.g., a specific previous birthday party). The second task instructed subjects to use the cue to think of a specific future scenario involving the cue. Activity common to both tasks (i.e., a conjunction of the past and future tasks) was contrasted with a third task that involved many of the processes common to past and future thought (e.g., mental construction of lifelike scenarios) but that lacked a sense of representing oneself in time. Specifically, the control task required participants to use the cue as a starting point for imagining former U.S. President Bill Clinton in a specific scenario. Bill Clinton was chosen because pretesting showed that he is easy to visualize in a variety of situations.

As can be seen in **Figure 3**, several regions in the brain's posterior cortex were similarly engaged during personal past and future thought, but not during the control task. These regions were located in the occipital cortex, the posterior cingulate cortex, and the medial temporal lobes. Previous research had shown that these regions are consistently engaged during tasks such as autobiographical memory (Svoboda et al., 2006) and mental navigation of familiar routes (Ghaem et al., 1997; Mellet et al., 2000;

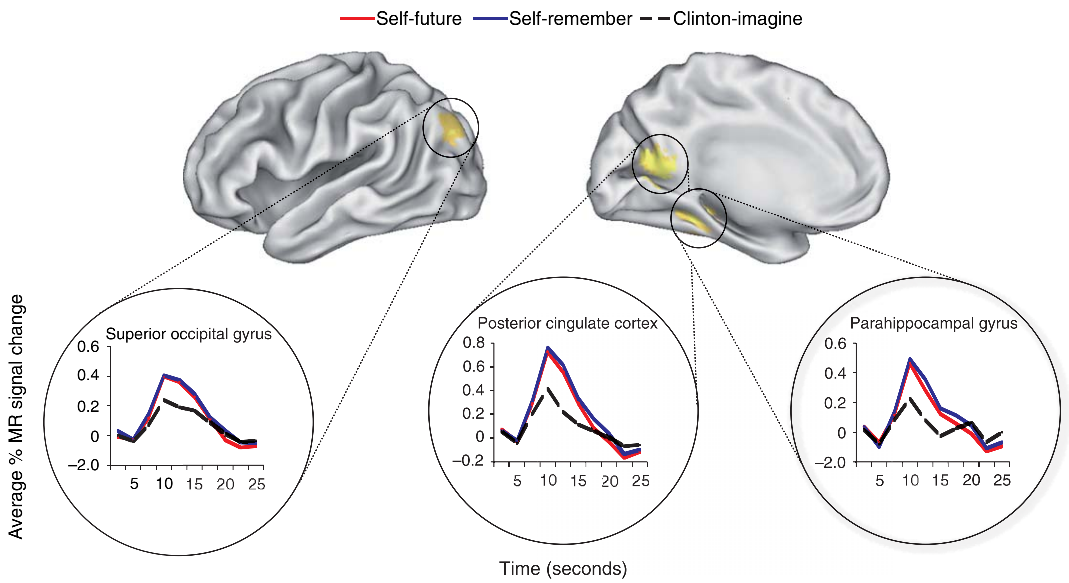

Figure 3 Percent signal change for brain regions exhibiting indistinguishable patterns of activity across time while participants envisioned their personal future and recollected the past. Imagining a familiar individual in similar scenarios resulted in a pattern of activity different from both the past and future tasks. Regions appear within superior occipital gyrus, posterior cingulate cortex, and parahippocampal gyrus. Data from Szpunar, Watson, and McDermott (2007).

Rosenbaum et al., 2004), which encourage participants to recount previously experienced settings (Aminoff et al., 2007). Szpunar et al. hypothesized that asking participants to envision a personal future scenario likely required similar processes. That is, in order to effectively generate a plausible image of the future, participants reactivate contextual associations from posterior cortical regions (cf., Bar and Aminoff, 2003; Okuda et al., 2003; Bar, 2004). Postexperiment questionnaires indicated that participants did tend to imagine future scenarios in the context of familiar settings and people.

A similar pattern of fMRI data has been presented by Addis et al. (2007), who parsed episodic future thought and remembering into two separate phases: construction and elaboration. That is, subjects were given cues (e.g., car) and asked to envision themselves in the future or to remember a past event. Once the event was in mind, they were to press a button and to then keep thinking about the event for the remaining time of the 20 s. They then rated the level of detail, the emotional intensity, and the perspective (first person or third person) before moving to the next trial. Of most interest to the present discussion is the construction phase (in part because the activity during the elaboration phase could not be separated from the activity during the three subsequent rating phases). Relative to baseline tasks that involved sentence generation and imagery, constructing the past and future episodes led to equivalent activity in a set of posterior cortical regions similar to those reported by Szpunar et al. (2007).

In light of such findings, Schacter and Addis (2007a) have proposed what they call the constructive episodic simulation hypothesis. They argue that one important function of retaining personal memories is the ability to sample their contents in mentally constructing (predicting) novel future scenarios (see also Szpunar and McDermott, in press). That past and future thought are so closely related provides insight into why certain populations who lack access to specific personal details of their past (e.g., brain damaged amnesic patients) are also unable to imagine specific personal future scenarios.

Finally, it should be noted that although this is a very recently emerging topic of interest, we anticipate that the above-mentioned studies will act as a catalyst for future research. Several early concept papers and reviews on the topic have also been put forth (Buckner and Carroll, 2007; Miller, 2007; Schacter and Addis, 2007a; Szpunar and McDermott, 2007). There is a recent but clear trend in thinking about episodic memory to include episodic future thought.

2.27.4.3 Development of Episodic Future Thought

A small but growing line of research suggests that the ability to project oneself into the future emerges in concert with the ability to vividly recollect the past. For instance, Busby and Suddendorf (2005) have shown that it is not until about the age of 5 years that children are able to accurately report what they will or will not do in the future (i.e., tomorrow), as well as what they have or have not done in the past (i.e., yesterday). Many of these studies have focused on requiring children to predict future states (e.g., Suddendorf and Busby, 2005) and have revealed both that the emergence of this capacity is not based simply on semantic knowledge related to the future event (Atance and Meltzoff, 2005) and that it is not dependent on language (Atance and O'Neill, 2005).

2.27.5 Is Episodic Memory Uniquely Human?

Perhaps the most intensely debated topic regarding episodic memory is whether this capacity, and mental time travel more generally, is uniquely human. There is no dispute that nonhuman animals possess memory. For example, consider a dog that buries a bone in the backyard and retrieves it the following day. How does the dog accomplish this task? Perhaps the animal mentally travels back in time, as we might. Alternatively, the animal may simply know that the backyard is somewhere where things are buried and may be able to make use of salient cues to locate the object it desires. Or the animal may know exactly where the bone is without remembering the episode in which it was placed there. We suspect most dog owners would suggest that the animal surely remembers where it had buried the bone and would likely be willing to offer many other examples to support the claim. But is this what happens?

As it turns out, this is a very difficult question to answer. If we assume that subjective (autonoetic) awareness is the central component of episodic memory, then we are not able to get very far. Much of the evidence for the concept of autonoetic awareness comes by way of verbal reports regarding the subjective state experienced during the act of remembering the past (e.g., remembering vs. knowing). Because we cannot directly ask a nonhuman animal to describe its mental state, the prospect of identifying autonoetic awareness in other species is dim (Clayton et al., 2005). This state of affairs has led some to argue that there should be other means by which to investigate episodic memory in nonhuman animals.

Clayton et al. (2003) suggest that one alternative is to characterize episodic memory in terms of the spatial–temporal information that is encoded about an earlier event (what, where, and when) and the nature by which this information is represented (i.e., as an integrated whole) and utilized. The authors argue that animal studies must consider these behavioral criteria if they are to demonstrate convincing evidence of episodic memory in nonhuman animals. Clayton et al. further review prior attempts using primates, rats, and other animals that fall short of meeting these criteria.

Clayton, Dickinson, and their colleagues have presented several impressive demonstrations of an integrative memory capacity in the western scrub jay (e.g., Clayton and Dickinson, 1998, 1999). In their studies, the scrub jays are given the opportunity to cache both preferable but perishable (e.g., wax worms) and nonpreferable but less perishable (e.g., nuts) foodstuffs (see **Figure 4**). Given that the scrub jays' preferred snack will perish sooner, the birds must remember not only what they stored and where they stored it, but also when the foodstuff had been stored. Although the scrub jays will prefer to search for their favored treat, there is little point if that snack is no longer edible. It appears that the scrub jays are able to integrate these aspects of the original caching episode and search accordingly. That is, the scrub jays are able to appropriately adjust recovery attempts of the differentially perishable caches depending on how long ago they had stored the food items.

Figure 4 A western scrub-jay caching wax worms.

Even such convincing evidence of an integrated spatial–temporal memory of the past leaves open questions regarding the mental life of this species of bird. As a result, Clayton et al. (2003; Clayton and Dickinson, 1998) refer to this capacity as episodic-like memory, while others question whether this feat represents episodic memory or some other mechanism that may be driven by specific learning algorithms (Suddendorf and Busby, 2003; Suddendorf, 2006; see also Tulving, 2005).

Tulving (2005) has suggested that although mental states cannot be reported by other species, they may in fact be inferred, particularly in the context of mental time travel into the future (e.g., Emery and Clayton, 2001; Dally et al., 2006). Specifically, Tulving argues that comparative studies of episodic memory per se may be futile, in that demonstrations of episodic-like memory in other species may be explained away by simpler mechanisms that need not evoke episodic memory in its true sense (involving autonoetic consciousness). However, it may be possible to construct a situation in which an animal's future-directed behavior may not be attributed to other, simpler means.

Achieving such a situation, however, is no simple matter. A great deal of evidence suggests that even our nearest primitive relatives are incapable of truly future-oriented behavior (for reviews see Roberts, 2002; Suddendorf and Busby, 2003). According to the Bishof-Kohler hypothesis, an animal's foresight is necessarily restricted because it cannot anticipate future needs (for a more in-depth discussion see Suddendorf and Corballis, 1997). For instance, although chimpanzees display preparatory behaviors for future food consumption, it is unclear whether such behaviors indicate foresight beyond the near future (e.g., Boesch and Boesch, 1984; Byrne, 1995). Based on a review of the relevant literature, Roberts (2002) also concluded that higher-order primates appear to be "stuck in time."

Future studies will require clever experimental designs that will allow researchers to examine whether a particular species is able to plan for the future in a manner that is not instigated or maintained by its present motivational state, and in the absence of any immediate benefits associated with a future-directed action (see Mulcahy and Call, 2006; Raby et al., 2007). As it stands, the capacity to mentally represent the personal past and future has only been convincingly demonstrated with human beings (usually over the age of 4 years). Although future research will provide us with a better understanding as to how unique this capacity is to humans, it will likely remain that this capacity holds a special status for humankind (Suddendorf and Corballis, 1997; Tulving, 2002a).

2.27.6 Concluding Remarks

As with all concepts of scientific inquiry, episodic memory is an evolving one that is largely shaped through the intricate relationship between data, theory, and available methods of inquiry. The concept of episodic memory started out as a taxonomic distinction that might possess some heuristic usefulness for future research. It has now expanded to encompass a dissociable system of the human brain that enables its owner to accomplish a feat (i.e., becoming autonoetically aware of episodes from one's past) that could not otherwise be possible. Currently, episodic memory represents a concept of great interest to many fields (e.g., clinical psychology, comparative psychology, developmental psychology, experimental psychology, functional brain imaging, neuropsychology, and psychopharmacology). There is little doubt that the continuing accumulation of data from these various areas of research, together with their unique methods of inquiry and furthering technological advancements, will ensure that researchers on the topic will continue to ask new and exciting questions.

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