

## **MEMORY AND TEMPORAL EXPERIENCE: THE EFFECTS OF EPISODIC MEMORY LOSS ON AN AMNESIC PATIENT'S ABILITY TO REMEMBER THE PAST AND IMAGINE THE FUTURE**

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This article examines the effects of memory loss on a patient's ability to remember the past and imagine the future. We present the case of D.B., who, as a result of hypoxic brain damage, suffered severe amnesia for the personally experienced past. By contrast, his knowledge of the nonpersonal past was relatively preserved. A similar pattern was evidenced in his ability to anticipate future events. Although D.B. had great difficulty imagining what his experiences might be like in the future, his capacity to anticipate issues and events in the public domain was comparable to that of neurologically healthy, age-matched controls. These findings suggest that neuropsychological dissociations between episodic and semantic memory for the past also may extend to the ability to anticipate the future.

Our experience of personal identity depends, in a fundamental way, on our capacity to represent the self as a psychologically coherent entity persisting through time, whose past experiences are remembered as belonging to its present self (e.g., Klein, 2001). The experience of self-continuity, in turn, provides the mental scaffolding from which we can imagine possible futures states in which we might be involved (for review, see Moore & Lemmon, 2001). Perhaps the best way to convey the

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This work was supported by an Academic Senate Research Grant to Stanley B. Klein from the University of California, Santa Barbara, and by National Institute of Mental Health Grant MH-35956 to John F. Kihlstrom. We would like to thank Mark Wheeler and Gianfranco Dalla Barba for their extremely helpful comments on earlier versions of this article. Address correspondence to Stanley B. Klein, Department of Psychology, University of California, Santa Barbara, CA 93106; E-mail: klein@psych.ucsb.edu.

importance of time and memory in our experience of self is to quote Tulving (2002).

... we can, if we wish, close our eyes and think about what we did ten minutes ago, or how we celebrated our last birthday. And we can think about what we might be doing tomorrow, or next year. This kind of sense of time makes a huge difference to what we are and how we live. If we retained all our other mental capacities, but lost the awareness of time in which our lives are played out, we might still be uniquely different from all other animals but we would no longer be human as we understand it. (pp. 311)

Thus, understanding the human experience of personal identity requires recognizing the memorial and temporal basis of that experience. In this article, we present a theoretical analysis and empirical investigation of the role played by memory in enabling the experience of self as temporally extended, as an entity spanning past, present, and future.

## MEMORY AND TIME

Memory and time have a special relationship. On the one hand, the act of remembering logically presupposes a sense of time (for reviews, see Furlong, 1951; Howe & Courage, 1997; James, 1890; McCormack & Hoerl, 1999). On the other hand, our subjective experience of time is held to be a construction of memory (for reviews, see Fraisse, 1963; Friedman, 1993; Larsen, Thompson, & Hansen, 1996; Ornstein, 1969). The concepts of memory and time are thus interdependent, neither completely separable from the other (e.g., Rosenfield, 1992; Sorabji, 1972). In this article we explore this interdependence by examining what happens when the relation between memory and time breaks down. In particular, we describe effects wrought by catastrophic memory loss on an amnesic patient's ability to remember the past and imagine the future.

Analyses of the effects of amnesia on temporal experience have tended to focus on the role of memory in enabling reconstruction of one's past (e.g., Barbarotto, Laiacona, & Cocchini, 1996; Dalla Barba, 1993; Hodges & McCarthy, 1995; Markowitsch, Fink, Thone, Kessler, & Heiss, 1997; Reinvang, Nielson, Gjerstad, & Bakke, 2000; Russell, 1971; Tulving, 1989; Wilson & Wearing, 1995). However, memory also serves a prospective function, enabling its owner to plan future actions and anticipate future events (for reviews, see Brandimonte, Einstein, & McDaniel, 1996; Ingvar, 1985; Suddendorf & Corballis, 1997; Tulving, 1985; Tulving &

Lepage, 2000). Indeed, a case can be made that information storage is intrinsically prospective, used to support future decisions and judgments that cannot be known in advance with certainty (e.g., Dawkins, 1976; Klein, Cosmides, Tooby, & Chance, 2002; Tulving & Lepage, 2000). Yet, despite its importance, the role of memory in imaging the future largely has been neglected in investigations of the amnesic syndrome (for exceptions, see Dalla Barba, Cappelletti, Signorini, & Denes, 1997; Talland, 1965; Tulving, 1985). We attempt to address this oversight by examining the effects of memory loss on both retrospective and prospective components of temporal experience.

### TYPES OF MEMORY, TYPES OF TEMPORAL EXPERIENCE

To appreciate the relation between memory and time, it is necessary to consider the types of temporal experience made possible by different forms of memory. Tulving (1983, 1993a, 1993b, 1995, 2000) has argued that it is useful to distinguish between two forms of long-term memory: episodic and semantic (see also Cermak, 1984; Markowitsch, 1995; Moscovitch, Yaschyshyn, Ziegler, & Nadel, 2000; Viskontas, McAndrews, & Moscovitch, 2000; Wheeler & McMillan, 2001; Wood, Ebert, & Kinsbourne, 1982). A key distinction between episodic and semantic memory is the nature of subjective temporal experience that accompanies their retrieval (e.g., McCormack & Hoerl, 1999; Tulving, 1993b, 1995; Tulving & Lepage, 2000; Wheeler & McMillan, 2001; Wheeler, Stuss, & Tulving, 1997).

Episodic retrieval is held to consist in knowledge of a previously experienced event along with an awareness that the event occurred in one's past. For example, recalling the occasion when I arrived late for an appointment requires that I have a mental state representing the particular event of being late along with an additional representation of that event as something that happened at a previous time in my life (see also Gennaro, 1992; Kihlstrom, 1997; Klein, 2001; Levine et al., 1998; McCormack & Hoerl, 1999; Perner, 1991; Suddendorf & Corballis, 1997). Episodic recollection thus enables a person to mentally travel back in time to relive previously experienced personal events (for reviews, see Tulving 1993b; Suddendorf & Corballis, 1997; Wheeler et al., 1997). It follows that impairments in episodic recollection should compromise one's ability to reexperience a personal past, and, as is well known, a considerable body of research shows that this indeed occurs (e.g.,

Cermak & O'Connor, 1983; De Renzi, Lucchelli, Muggia, & Spinnler, 1995; Kitchener, Hodges, & McCarthy, 1998; Klein, Loftus, & Kihlstrom, 1996; Levine et al., 1998; Markowitsch et al., 1993; Talland, 1970; Tulving, 1989; Viskontas et al., 2000; Wheeler et al., 1997).

In addition to enabling mental time travel into one's past, episodic memory also is hypothesized to provide a foundation for imagining what one's experiences might be like in the future (e.g., Dalla Barba, 2000; Suddendorf, 1994; Suddendorf & Corballis, 1997; Tulving, 1985, 1993b; Tulving & Lepage, 2000; Wheeler et al., 1997). Although few studies have examined the proposed relation between episodic memory and awareness of a personal future, those that have are generally supportive. For example, Dalla Barba et al. (1997) report the case of patient G.A., who developed an amnesic-confabulatory syndrome following a rupture of her anterior communicating artery. Testing revealed that G.A.'s confabulations were confined primarily to tasks requiring her to access her personal past or plan her personal future. For example, in response to the question "What are you going to do tomorrow?" she replied "I will go out shopping alone by car" (Dalla Barba et al., 1997, p. 430), despite the fact that since her disease she had never gone shopping alone and certainly would not have been allowed to do so given her medical condition.

Another source of evidence comes from observations of patient K.C., who, as a result of a severe brain injury, lost his entire fund of episodic memory, rendering him unable to bring to mind a single personal experience from any point in his past (e.g., Tulving, 1985, 1989, 1993b; Tulving, Hayman, & MacDonald, 1991). When informally interviewed concerning his plans for the future, K.C. was unable to imagine anything he was likely to do on any subsequent occasion (Tulving, 1985).

Although the temporal experiences attributed to patients G.A. and K.C. differ in certain respects—G.A. has some awareness of her future (albeit one comprising events incongruous with her personal history and present situation), whereas for K.C. the future has ceased to exist—they are similar in suggesting that disruption of episodic memory can compromise the ability to project one's existence into the future.

In contrast to episodic recollection, retrieval from semantic memory does not entail awareness that one is in a mental state that represents something in one's past. Rather, it is experienced as generic knowledge about the world (e.g., facts, people, events) without an accompanying thought that this information is known because it has been experienced

before (e.g., Klein, Chan, & Loftus, 1999; Perner & Ruffman, 1994; Tulving 1993a, 1993b, 1995; Tulving & Lepage, 2000; Wheeler, 2000; Wheeler et al., 1997). Much of the knowledge provided by semantic memory is atemporal (e.g., words, concepts). However, semantic memory does include temporal information about events and issues that took place in the past, thus allowing one to orient events in time without reexperiencing them as part of one's personal history (e.g., knowing that President Clinton was elected to office in November 1992 without reliving the experience of his election; e.g., Tulving, 1993a, 1993b, 1995; Tulving & Lepage, 2000; Wheeler et al., 1997). In this article we refer to the experience of time associated with semantic memory as *known time* to distinguish it from the experience of *lived time* made possible by episodic memory. It is the distinction between thinking about time as an objective chronology and thinking about time as an unfolding of personal happenings centered about the self.

Support for this distinction is readily found in the neuropsychological literature. As already noted, patients with episodic amnesia experience great difficulty recollecting events from their personal past. By contrast, their knowledge of public events and issues (e.g., Clinton's election, health care reform) that transpired during the period of time covered by their amnesia often is spared (e.g., Evans, Wilson, Wraight, & Hodges, 1993; Hirano & Noguchi, 1998; Kitchener et al., 1998; Markowitsch et al., 1993; Markowitsch et al., 1997; McCarthy & Warrington, 1992; Van der Linden, Bredart, Depoorter, & Coyette, 1996; Venneri & Caffarra, 1998).<sup>1</sup>

Semantic memory also has been hypothesized to mediate our ability to project our knowledge of the world into a vision of what the nonpersonal future might be like (e.g., Tulving, 1993b; Tulving & Lepage, 2000). Semantic memory should thus make it possible to mentally simulate future states of the world from the perspective of an observer rather than from that of a participant. To date, however, no

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1. The opposite form of the dissociation between the lived and known past is found in patients with impairments restricted to semantic memory: These patients show impaired access to the known past accompanied by normal or near-normal recollection of the lived past (e.g., Hodges & McCarthy, 1995; Kitchener & Hodges, 1999; Markowitsch, Calabrese, Neufeld, Gehlen, & Durwen, 1999). Taken together with the findings from cases of episodic amnesia, one interpretation of the double dissociation is that the lived past and the known past are represented independently in memory and perhaps mediated by separate cognitive systems.

evidence is available regarding the hypothesized relation between semantic memory and the capacity to imagine the future.

In this article, we investigated the relation between memory and temporal experience by studying an amnesic patient, D.B., who suffered a profound loss of episodic memory as a result of cardiac arrest with presumed hypoxic brain damage. By contrast, his semantic memory function was relatively spared. On the basis of a large body of previous research, we predicted that D.B. would show impaired access to the lived past, but intact access to the known past.

The novel contribution of our study concerned the effects of episodic amnesia on D.B.'s capacity to imagine both a lived and a known future. With respect to the lived future, the few studies available (Dalla Barba et al., 1997; Tulving, 1985) led us to predict that D.B. would find it difficult to imagine what his future experiences might be like. With respect to the known future, our predictions were necessarily more speculative because, as noted earlier, there is no direct evidence from the neuropsychological literature bearing on this topic. However, extrapolating from what is known about the impact of episodic amnesia on the ability to know about the past (e.g., Hirano & Noguchi, 1998; Markowitsch et al., 1993), we hypothesized that D.B. would be able to anticipate future events provided those events did not involve him personally.

## CASE STUDY

### Patient D.B.

D.B. is a 78-year-old right-handed male who collapsed while playing basketball at a local park. When the paramedics arrived, they found D.B. to be in ventricular fibrillation and without pulse. CPR was administered and his pulse returned. A diagnosis of cardiac arrest with presumed anoxic encephalopathy was made (for case details, see Klein, Rozendal, & Cosmides, 2002).

A CT scan was administered to evaluate a laceration to the head suffered when he collapsed after losing consciousness. No acute intercranial abnormality was detected.<sup>2</sup> He made a successful physical recovery and 2 ½ weeks later was discharged from the hospital into the care of his daughter.

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2. In a second CT scan, conducted approximately 4 mo later, the ventricles and sulci appeared mildly prominent, suggesting mild central and peripheral atrophy.

D.B. was referred to the first author (S.B.K.) for neuropsychological evaluation of memory complaints. On examination he was alert and cooperative, but demonstrated profound difficulty remembering personal events. Informal questioning and psychological testing (see following) revealed that he was unable to consciously bring to mind a single thing he had done or experienced before his heart attack. In addition to this dense retrograde amnesia, D.B. also had severe anterograde amnesia, rendering him incapable of remembering events that transpired only moments earlier.

In contrast to his profound episodic impairment, D.B.'s semantic knowledge seemed relatively spared by his illness. His speech was fluent and his general level of intelligence appeared to be preserved. His knowledge of word meanings was intact, as was his ability to understand and respond to questions. Informal interviews revealed that he knew a variety of facts about public figures and events, but he could not consciously bring to mind a single experience involving any of those facts. For instance, he knew the name of the company where he had worked and the nature of its business, but could not recall a single occasion when he was at work, or a single event that occurred there (for details, see Klein, Rozendal, & Cosmides, 2002).

### **Control Participants With No Memory Loss**

Two neurologically healthy age-matched ( $M = 75$  years) and education-matched ( $M = 16$  years, D.B. = 15 years) controls were tested on the same battery of memory tests that were administered to D.B.

### DOCUMENTING D.B.'S MEMORY DEFICITS

To evaluate D.B.'s memory function, we administered the following battery of memory tests to him and to the two control participants. Testing was conducted approximately 2 months after D.B. had suffered his heart attack. Participants were tested individually. All participants gave informed consent before participating in the study.

### **Anterograde Memory Function**

*Digit Span.* Immediate memory was evaluated using a digit-span technique (e.g., Weschler, 1981). An experimenter read aloud to the participants a list of digits at a rate of one every 2 s, beginning with a list of two

digits. The participant was then to immediately repeat back the digits in the order they were presented. If the list was repeated correctly, the experimenter read another list of digits, increasing the length of the list by one digit. Testing continued until the participant failed to repeat a list correctly. D.B.'s digit span performance (6 digits) was comparable to that of control participants ( $M = 6.5$  digits,  $SD = .71$ ).

*Free Recall.* Participants' ability to retain information beyond the span of immediate memory was examined using a supraspan free-recall procedure (e.g., Crowder, 1976). Participants were presented with three lists of 16 unrelated nouns. Each list was read aloud by the experimenter at the rate of one noun every 2 s. Immediately following presentation of the last item in a list, participants were given 1 min to verbally recall as many of the items from the list as possible, in any order. Each participant's recall performance was plotted as a serial-position curve, which shows the probability of an item being correctly recalled as a function of its serial position in the input list.

Figure 1 shows the free recall performance of D.B. and control participants. Consistent with impressions from informal interviews, D.B.'s performance revealed profound anterograde memory impairment: His average recall per list ( $M = 1.67$ ) was almost 2.5 standard deviations below that for control participants ( $M = 6$ ;  $SD = 1.79$ ). Moreover, D.B.'s recall was limited to the last three items presented from each list; in contrast, the controls produced normal serial position curves, with recall best for words from the beginning and end of a list.

*Recognition Memory.* Although amnesic patients are known to perform poorly on both recall and recognition tests of new learning (e.g., Parkin, 1987), several cases have been reported in which recognition memory is better preserved (e.g., Aggleton & Shaw, 1996; Hanley & Davies, 1997; Hirst et al., 1986). To test whether D.B.'s difficulties recalling newly presented material extended to his recognition memory performance, D.B. was read aloud a list of 16 unrelated nouns at the rate of one noun every 2 s. We instructed him that we were testing his ability to learn words and that he should repeat each word aloud as it was read and try to remember it. Following a 5 min delay, the recognition phase of the study began. We read D.B. a list of 32 nouns, one noun at a time. Half of the nouns were "old" (presented during the learning phase) and half were "new" (not previously presented). For each noun, D.B. was asked to judge (yes/no) whether it had been previously presented. He was given as much time as he required to make a decision.



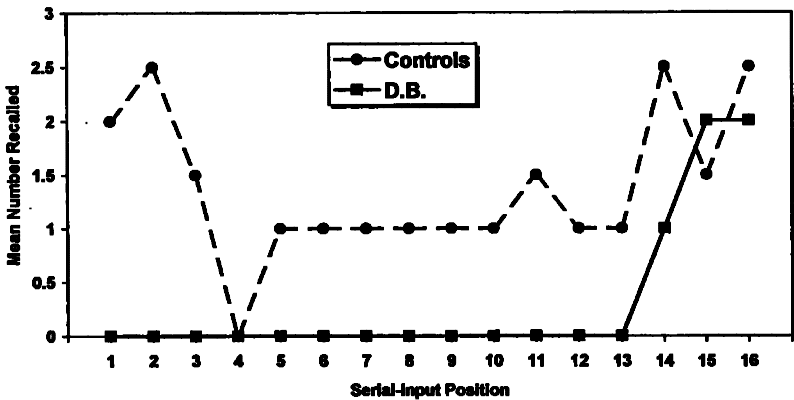


FIGURE 1. Serial-position curve, showing mean number of nouns recalled by D.B. and control participants as a function of serial-input position.

D.B.'s initial response to each noun presented for recognition was that he had no memory of seeing the word previously. When encouraged to guess, his performance was close to chance; he correctly identified 38% (6 out of 16) of the "old" nouns and 56% (9 out of 16) of the "new" nouns (chi-square [1] = 1.25, *ns*). D.B.'s anterograde memory for information beyond the span of immediate memory thus appears severely compromised regardless of whether assessed by recall or recognition tasks.

### Retrograde Memory Function

*Semantic Memory.* To investigate access to semantic knowledge, we selected two tasks (category judgments and speeded sentence verification) from the battery of semantic memory tests used by Wilson and Baddeley (1988), and one task (the semantic version of the Galton-Crovitz memory-cuing test) from the battery compiled by Dalla Barba, Cappelletti, Signorini, and Denes (1997).

In the category judgment task, participants were shown 24 pairs of words and, for each pair, were asked to decide whether the word belonged to the same semantic category (e.g., fruits, colors). Half of the pairs contained words from the same semantic category (e.g., apple-grape), and half contained words from different categories (e.g., ti-

ger-boat). D.B. responded correctly to 20 of the 24 word pairs, suggesting some deterioration from his presumed premorbid level (control participant performance was at ceiling).

In the speeded sentence verification task, participants were read a list of 24 simple sentences. After hearing each sentence, participants decided whether the idea it expressed was true or false. Half of the sentences were true (e.g., "Canaries can sing") and half were false (e.g., "A triangle is a round object"). Participants were told to state their decisions as quickly as possible, and both their decisions and decision latencies were recorded.

The results of the speeded sentence verification task produced a somewhat mixed picture. With respect to accuracy, D.B. and the controls both performed at ceiling. However, D.B. required longer than controls to make his decisions: D.B.'s mean verification latency ( $M = 1.73$  s) was approximately 1.5 standard deviations longer than that of the controls ( $M = 1.39$  s;  $S.D. = .21$  s).

In the semantic version of the Galton-Crovitz memory-cuing test, participants were presented with 6 cue words (discovery, war, king, revolution, assassination, president). For each word, they were asked to produce a detailed account of a specific historical event that had occurred before they were born. Responses were scored by two independent raters on a 0-2 scale, with 2 points given for a detailed description of the event, 1 point for a less detailed description, and 0 points for a general statement or if nothing was provided.

Both control participants received perfect scores (12 points), providing detailed accounts of historical events for each of the cue words presented. Unfortunately, because of a medical situation that arose during presentation of the fourth cue word, D.B.'s session was terminated prior to completion. For the three cue words to which he did respond, D.B. showed moderate impairment (he received 3 of the 6 points that could be awarded). For example, in response to the cue word war, D.B. provided an accurate and detailed account of events related to the Civil War (e.g., participants, issues of slavery, etc.). By contrast, the cue word discovery elicited the response "explorers from Great Britain discovered North and South America around 1812."

*Episodic Recollection of Personally Experienced Events.* To test memory for personal episodes, we used a modified version of the autobiographical memory-cuing task originated by Galton (1879; see also Crovitz & Schiffman, 1974; Klein et al., 1996; Robinson, 1976; Schacter, Kihlstrom,

Canter Kihlstrom, & Berren, 1989). Participants were told that we were interested in studying memory for autobiographical experiences. They were then informed that a series of words would be read to them and that they should try to think of a specific personal event from any time in their past that was related to each word. They were instructed to provide a brief verbal description of each memory and to date the memory as accurately as possible. Examples were given prior to the start of the recall trials.

The cue words were 24 common English words, randomly selected from the set of 48 cue words presented by Robinson (1976). The cues included 8 affect words (e.g., surprised, lonely), 8 object words (e.g., car, river), and 8 activity words (e.g., sing, run). All participants received the same set of 24 cues in a fixed-random order. Participants were read the list of 24 cue words, 1 word at a time.

When a participant failed to provide a memory that was specific with respect to time and place (e.g., in response to the cue "lonely," the participant responds, "I'm lonely when I'm with people I don't know well"), prompts were used to encourage participants to be more specific (e.g., "Can you remember a particular time and place when you were lonely around someone you didn't know well?"). If on any trial a participant was unable to retrieve a memory within 2 min, the trial was terminated and the participant was read the next cue.

Two judges, blind to the goals of the study, scored the memories on the following criteria: (a) specificity with respect to time, (b) specificity with respect to place, and (c) self-reference. Recall protocols were scored according to a lenient criterion in which a memory was designated episodic if it satisfied at least two of the three criteria. Excellent reliability was obtained, with the judges agreeing on 96% of the items scored.

Control participants had no difficulty with this task, producing recollections satisfying all three episodic scoring criteria in response to all 24 cue words. D.B.'s performance, by contrast, differed radically from that of the controls. Despite encouragement and prompting, he was unable to recollect a single experience from any point in his life. On those few occasions (6 out of 24) on which D.B. responded to a cue, his responses were judged by family members to be confabulations composed of novel combinations of temporally disjointed fragments from his remote past. Thus, in contrast to his performance on the semantic version of the Galton-Crovitz task (which, though impaired, demonstrated some

knowledge of historical events), D.B.'s performance on the episodic version of the task was profoundly deficient.

Taken together, tests of D.B.'s anterograde and retrograde episodic memory performance document a profound impairment in his ability to recollect personal events that transpired both prior to and following his illness (e.g., he was unable to recollect a single event on the episodic version of the Galton-Crovitz task). By contrast, his semantic memory was better preserved: Although D.B.'s performance clearly was impaired in comparison to that of healthy control participants, his knowledge of facts about the world (both generic and historical) and word meanings was relatively intact. It is against this background that we turn to an examination of his ability to remember the past and to imagine the future.

## EXAMINATION OF MEMORY AND TEMPORALITY

We investigated the relation between memory loss and temporality using a battery of tests designed to assess the temporal aspects of lived and known experience. Questions concerning present orientation in time, memory of the lived past, and anticipation of the lived future were compiled from materials developed by Dalla Barba and his colleagues (Dalla Barba, 1993; Dalla Barba et al., 1997; Dalla Barba, Nedjam, & Dubios, 1999). Questions concerning the known past and the known future were constructed by the authors (tasks are presented in Appendix A).

### ORIENTATION IN TIME

D.B. and the two control participants were asked six questions probing their orientation in time (e.g., day, month, year). Consistent with informal observations, D.B. showed disorientation to time: Although he correctly identified the hour of the day, the month of the year, and the season of the year, he did not know the day, the year, or his age. Control participants completed the temporal orientation questionnaire without error.

### LIVED PAST AND LIVED FUTURE

We hypothesized that D.B.'s amnesia for the lived past also would compromise his ability to imagine a lived future. To test this hypothesis, we administered two further tasks to D.B. and the control participants: (a) a 10-item questionnaire requiring participants to recollect personal events

from their past, and (b) a 10-item questionnaire requiring participants to imagine personal events in their future. Items on the past and future versions of the questionnaire were matched for temporal displacement from the moment the question was asked (e.g., "What did you do yesterday?" and "What are you going to do tomorrow?" for the past and future versions, respectively). Answers were scored as "correct," "confabulation," or "don't know" according to whether they were consistent with information (collected from family members) concerning the participant's past, present, and probable future activities.

With regard to thinking about the future, it might seem that any answer could qualify as a "confabulation" because there is no way to be certain of the correctness of answers given in response to questions about events that have yet to take place. However, judgments about the future can be considered "correct" in terms of the perceived probability of the occurrence of possible events or "confabulatory" when they do not conform to those probabilities (e.g., Dalla Barba et al., 1997; Dalla Barba et al., 1999). For example, in response to the question "When will be the next time you visit a doctor?" D.B. replied, "Sometime in the next week." His daughter confirmed that D.B. did have an appointment with a physician scheduled for the following week, and so this was scored a "correct" response. By contrast, when asked "Who are you going to see this evening?" D.B. replied, "I'm going to visit my mother." Because his mother had died almost 2 decades earlier, his response was scored as a confabulation concerning his future.

The results are presented in the top panel of Table 1. As can be seen, D.B.'s episodic impairment was reflected in his performance on both the past and future versions of this task. In response to questions about his personal past, D.B. correctly recalled only one memory (in answer to the question "What did you do a few minutes ago?" he replied, "I think I was talking with you [i.e., the experimenter]"). Of the remaining 9 questions, 3 were scored "confabulations" and 6 produced no memories at all. Control participants, by contrast, had no difficulty with the task, producing episodic recollections in response to all 10 questions.

Participants' responses to questions about their future presented a similar picture (see bottom panel of Table 1). D.B. again showed considerable impairment, providing only 2 responses judged by family members to be consistent with his probable future activities. For the remaining 8 questions, 5 produced responses judged to be confabulations and 3 elicited "don't know" responses (a similar pattern of findings

TABLE 1. Responses to 10 Questions Concerning the Lived Past and the Lived Future

Participants	Response		
	Correct	Incorrect	
		Confabulation	Don't Know
<b>Lived Past</b>			
D.B.	1	3	6
Controls	10	0	0
<b>Lived Future</b>			
D.B.	2	5	3
Controls	10	0	0

is reported for patient G.A.; Dalla Barba et al., 1997). Control participants performed at ceiling, providing "correct" responses to all 10 questions about their future.

#### KNOWN PAST AND KNOWN FUTURE

Our second hypothesis was that episodic memory impairment should not affect a person's ability to access the known past or the known future. Rather, these abilities are held to depend on the operations of semantic memory. Because D.B.'s semantic memory was much better preserved than his episodic memory, we predicted that his performance on tasks requiring him to know about public issues and events that took place in the past or were likely to happen in the future would be slightly below that of control participants, but considerably better than his performance on tasks requiring access to the lived past and lived future.

To examine this, we constructed a 7-item questionnaire that required participants to describe issues and events in a variety of public domains (e.g., medicine, technology, politics). We constructed two versions of the task that differed only with respect to temporal orientation of the questions: In the "past" version of the task, participants were asked to focus on issues and events that had taken place during the past 10 years, whereas in the "future version," participants had to describe issues and events they believed likely to take place over the next 10 years. All responses were judged for plausibility—that is, whether responses reflected issues and events that actually had taken place in the past or

could reasonably be expected to occur in the future—by two raters blind to the purposes of the study (input from family members was used to establish the plausibility of responses to questions about issues and events related to participants' communities). Agreement between the raters was 100%.

The results are presented in Table 2. In contrast to his performance on tests of the lived past, D.B.'s access to the known past seemed relatively intact: He provided correct answers to 4 out of 7 questions and "don't know" responses to the remaining 3. Moreover, all his answers accurately reflected issues and events that had been prominent in the public domain over the past decade. For example, in response to the question "Can you tell me what you think were some of the most important issues facing your community over the last ten years?," D.B. listed two topics—housing and jobs—both of which had been the subject of considerable debate in his community for a number of years.

On the future version of the test, D.B.'s performance was almost at ceiling: Six of his 7 responses were scored "correct" (the remaining question produced a "don't know" response). It is important to note that D.B.'s responses were not simply restatements of answers he provided to questions on the past-oriented version of the test, but rather indicated a capacity to anticipate changes in existing conditions. For example, in response to the question "Can you tell me what you think were some of the most important issues facing the environment over the last ten years?" he answered, "Overpopulation and the lack of public awareness about environmental issues." By comparison, the future-oriented version of this question elicited the response "threat that weather and rainfall patterns are going to change because of industrial pollution." (A summary of the topics mentioned by D.B. in response to questions about the known past and known future is presented in Appendix B.) It thus seems fair to conclude that D.B. can imagine a future that is different from what he knows about the past.<sup>3</sup>

For an additional perspective on D.B.'s capacity to remember the past and imagine the future, we compared (a) his performance on the test of the known past with his performance on the test of the lived past, and (b) his performance on the test of the known future with his performance on

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3. Along these lines, it is interesting to note that D.B. provided different answers to the "past" and "future" versions on 4 of the 7 questions presented—a performance comparable to that of the controls.

TABLE 2. Responses to 7 Questions Concerning the Known Past and the Known Future

Participants	Response		
	Correct	Incorrect	
		Confabulation	Don't Know
<b>Known Past</b>			
D.B.	4	0	3
Controls	7	0	0
<b>Known Future</b>			
D.B.	6	0	1
Controls	7	0	0

the test of the lived future. For purposes of analysis, "confabulation" and "don't know" responses were combined into a single category ("incorrect" responses), which was compared with "correct" responses. In both comparisons, D.B. performed significantly better on measures of temporal experience that depended on semantic memory (chi Square [1] = 4.41 and 7.14,  $p$ 's < .05, for the past and future comparisons, respectively).<sup>4</sup>

## DISCUSSION

This article reports the case of patient D.B., who was diagnosed with presumed hypoxic brain damage following a heart attack. As a consequence, he suffered a particularly dense amnesia affecting his memory for personal events which occurred both before and after his illness. In contrast, his general knowledge and language skills appeared relatively intact.

To document D.B.'s memory deficits, we administered a battery of tests designed to assess both anterograde and retrograde memory function. Testing revealed that he had profound difficulty remembering events and experiences from his own past, but was able to provide accurate information about a number of issues and events that had been in

4. Because of the small sample size, we also conducted a Fisher exact probability test on the data. The results paralleled those obtained from the chi-square analysis:  $p = .06$  and  $.013$  for the past and future comparisons, respectively.



the public domain. This pattern of selective memory impairment—a loss of the lived past accompanied by relative sparing of the known past—is consistent with a large body of research from experimental and cognitive neuroscience documenting dissociations between episodic and semantic memory functioning in amnesia (for reviews, see Foster & Jelicik, 1999; Hodges & McCarthy, 1995; Schacter & Tulving, 1994; Wheeler & McMillan, in press).

The novel contribution of the present study concerns the effects of D.B.'s amnesia on his ability to imagine the future. In parallel with his difficulties remembering his personal past, D.B. had severe difficulty imagining what his experiences might be like in the future (for related findings, see Della Barba et al., 1997; Tulving, 1985). By contrast, his capacity to anticipate issues and events in the public domain was virtually indistinguishable from that of neurologically healthy, age-matched controls. These findings represent the first demonstration that neuropsychological dissociations between memory for the lived and known past also may extend to the ability to anticipate the future.

#### RELATION OF THE PRESENT FINDINGS TO CURRENT HYPOTHESES ON THE INTERPLAY BETWEEN MEMORY AND TEMPORAL EXPERIENCE

The findings reported in this case study extend our understanding of the relation between memory and temporality. In an influential series of papers, Tulving (e.g., Tulving, 1985; 1993a, 1993b; 1995; Tulving & Lepage, 2000; Wheeler et al., 1997) argued that episodic memory differs from other forms of memory in that it alone enables one to relive personal events from the past and mentally project one's existence into the future. Tulving (1985, 1993b; see also Wheeler, 2000) has coined the term *autonoesis* to describe the type of awareness accompanying episodic recollection that enables a person to mentally travel through subjective time. The impairment of personal temporal orientation suffered by patient's like K.C. and D.B. can thus be attributed to a disturbance in autooetic consciousness.

Our research suggests that semantic memory also makes possible a form of mental time travel, albeit one that does not entail awareness of the temporal dimension of one's own experience. Specifically, individuals who possess semantic memory are capable of knowing about, but not

reexperiencing, previous states of the world and drawing on that generic knowledge to construct possible scenarios of the future. It thus would seem that the ability to mentally travel back and forth in time is not wedded to a particular form of memorial experience; rather, there appear to be qualitatively different types of temporal experience associated with different forms of memory.

It is also worth considering the present findings in light of recent theoretical work by Dalla Barba and colleagues (e.g., Dalla Barba et al., 1997; Dalla Barba et al., 1999) on the relation between consciousness, memory, and temporal experience. These authors call attention to two modes of consciousness, which they term temporal consciousness (TC) and knowing consciousness (KC). TC is consciousness of time—it enables a person to become aware of something as part of his or her personal past, present, or future. KC, by contrast, does not locate objects in time. Rather, it enables a person to become aware of something as an element of knowledge without that knowledge being situated in a temporal framework.

TC and KC can be thought of as two different ways of addressing the contents of long-term memory storage. Long-term memory is held to contain representations that vary in terms of their stability and resistance to modification (e.g., Dalla Barba et al., 1997; Dalla Barba et al., 1999). The more stable, overlearned representations can be thought of as roughly analogous to what Tulving (1983) terms semantic knowledge, whereas less stable, more malleable representations can be viewed as episodic-like in nature. In Dalla Barba's model, the experience of remembering the personal past and anticipating the personal future results when TC takes as its object less stable, episodic-like representations in long-term memory. However, there is nothing in Dalla Barba's model that precludes TC from taking as its object more stable, semantic-like representations. When this happens, the individual is able to chronologically locate well-learned facts about the world in a temporal matrix that extends from the impersonal past to the impersonal future.

Dalla Barba's model explains the dissociation between lived and known temporality experienced by patient D.B. as a result of a condition in which TC is intact, but is unable to access episodic-like representations in long-term memory. It still can, however, be applied to semantic knowledge such as public and historical facts. Under these circumstances, D.B. remains capable of knowing what happened in the past

and what might take place in the future, despite being unable to reexperience a personal past or imagine a personal future.

#### POTENTIAL LIMITATIONS AND FUTURE DIRECTIONS

Moscovitch and his colleagues (e.g., Moscovitch, 1995; Moscovitch & Melo, 1997) have argued that tests of episodic and semantic memory differ in the cognitive demands they place on the test taker. Specifically, tests of episodic memory are more likely to ask questions about temporal experience and require a response in narrative form (Moscovitch, 1995), and thus are more likely to require strategic retrieval processes. By this view, D.B.'s greater difficulty responding to the episodic version of the temporal experience questionnaire might be attributable to the greater cognitive demands of the test rather than to differential impairment of episodic and semantic memory function.

Although this possibility cannot be ruled out by the present findings, there are reasons to favor an episodic memory-impairment explanation of our data. First, both the episodic and semantic versions of our temporal experience questionnaire probed temporal knowledge and encouraged narrative responding. Second, Dalla Barba and his colleagues (Dalla Barba et al., 1997; Dalla Barba et al., 1999) have shown that even when the strategic retrieval demands made by episodic and semantic tests of memory have been equated, deficits restricted to episodic memory are still found among patients suffering amnesia. This suggests that the differential pattern of impairment evidenced by D.B. (who received tests derived from materials compiled by Dalla Barba) is not an artifact of test demands.

One way for future research to more fully address the strategic retrieval deficit hypothesis would be to look for evidence of a double dissociation between memory and temporal experience. Specifically, if the arguments we have presented in this article are correct, it follows that patients with selective impairments of semantic memory (e.g., DeRenzi, Liotti, & Nichelli, 1987; Hodges & Patterson, 1997; Kitchener & Hodges, 1999; Markowitsch, Calabrese, Neufeldt, Gehlen, & Durwen, 1999; Snowden, Griffiths, & Neary, 1996) should be able to imagine what their personal experiences might be like at a later time, yet have difficulty constructing plausible future scenarios that do not involve the self. If such a result were obtained, it would provide strong converging support for

the proposed relation between types of memory and types of temporal experience.

It is important to note that assessment of D.B.'s ability to anticipate the future was based on relatively few data points (a 7-item questionnaire). We currently are working on systematic replication with a larger pool of questions to enhance both the reliability and generality of our findings. Nonetheless, as the first study (to our knowledge) examining the contributions of episodic and semantic memory to the human experience of past and future, the findings reported here offer important new insights into the complex relation between memory and time (for a general review of this relation, see Hoerl & McCormack, 2001).

## CONCLUSIONS

In his "Speech to the Virginia Convention" (March 23, 1775), the American patriot and statesman Patrick Henry asserted, "I have but one lamp by which my feet are guided, and that is the lamp of experience. I know no way of judging of the future but by the past" (Bartlett, 1919/2002, p. 457). On the evidence of patient D.B., Patrick Henry had it right. There appears to be a close relationship between the ability to remember the personal past and the ability to imagine the personal future: In the absence of the former, the latter is severely compromised (see also, Tulving, 1985).

It is possible that both episodic remembering and imagining the future are mediated by a single ability for mental time travel. On the other hand, it may be that our ability to imagine our future prospects is predicated on our ability to remember our past experiences. Clinical psychologists have long understood that the best predictor of future behavior is past behavior (e.g., Meehl, 1954). In the same way, it may be that we can only predict our future by virtue of remembering our past. D.B. cannot resolve this issue for us, but he does raise the question of the cognitive basis of future time perspective. In this way, as in other ways (e.g., Klein & Kihlstrom, 1998), amnesic patients shed unique light on personality and social processes, as well as cognitive ones.

## APPENDIX A

### Temporal Orientation Questionnaire

1. What day of the week is it?
2. What month is it?
3. What year is it?
4. What season of the year is it?
5. What time is it?
6. How old are you?

### Lived Past Questionnaire

1. What did you do a few minutes ago?
2. Who did you see this morning?
3. What did you eat for dinner yesterday?
4. What did you do yesterday?
5. What did you do the day before yesterday?
6. How did you spend last Christmas?
7. Do you remember the last time you went to see a doctor?
8. Do you remember the last time you went to visit a friend or a relative?
9. Do you remember the last time you went to a restaurant?
10. Do you remember the last time you took a vacation?

### Lived Future Questionnaire

1. What are you going to do in a few minutes?
2. Who are you going to see this evening?
3. What are you going to eat this evening?
4. What are you going to do tomorrow?
5. What are you going to do the day after tomorrow?
6. How will you spend next Christmas?
7. When will be the next time you visit a doctor?
8. When will be the next time you visit a friend?
9. When will be the next time you go to a restaurant?
10. When will be the next time you go on vacation?

### Known Past Questionnaire

1. Can you tell me what you think were some of the most important political events of the last ten years?

2. Can you tell me what you think were some of the most important issues facing your community over the last ten years?
3. Can you tell me what you think were some of the most important issues facing our country over the last ten years?
4. Can you tell me what you think were the most important medical breakthroughs of the last ten years?
5. Can you tell me what you think were some of the most important issues facing our planet over the last ten years?
6. Can you tell me what you think were the most important innovations in technology over the last ten years?
7. Can you tell me what you think were the most important issues facing the environment over the last ten years?

### **Known Future Questionnaire**

1. Can you tell me what you think will be some of the most important political issues of the next ten years?
2. Can you tell me what you think will be some of the most important issues facing your community in the next ten years?
3. Can you tell me what you think will be some of the most important issues facing our country in the next ten years?
4. Can you tell me what you think will be the most important medical breakthroughs likely to take place in the next ten years?
5. Can you tell me what you think will be some of the most important issues facing our planet in the next ten years?
6. Can you tell me what you think will be the most important changes in technology in the next ten years?
7. Can you tell me what you think will be the most important issues facing the environment in the next ten years?

## **APPENDIX B**

### **SUMMARY OF TOPICS DISCUSSED IN RESPONSE TO THE KNOWN PAST AND THE KNOWN FUTURE QUESTIONNAIRES**

#### **Known Past Questionnaire**

1. Can you tell me what you think were some of the most important political events of the last ten years?  
D.B.: "Don't know."
2. Can you tell me what you think were some of the most important issues facing your community over the last ten years?  
D.B.: "Affordable housing; jobs"

3. Can you tell me what you think were some of the most important issues facing our country over the last ten years?  
D.B.: "Crime; jobs; education"
4. Can you tell me what you think were the most important medical breakthroughs of the last ten years?  
D.B.: "Don't know"
5. Can you tell me what you think were some of the most important issues facing our planet over the last ten years?  
D.B.: "Depletion of natural resources: air pollution; rainforests"
6. Can you tell me what you think were the most important innovations in technology over the last ten years?  
D.B.: "Don't know"
7. Can you tell me what you think were the most important issues facing the environment over the last ten years?  
D.B.: "Overpopulation; lack of public awareness about environmental issues"

### Known Future Questionnaire

1. Can you tell me what you think will be some of the most important political issues of the next ten years?  
D.B.: "Don't know"
2. Can you tell me what you think will be some of the most important issues facing your community in the next ten years?  
D.B.: "Population growth; housing; jobs"
3. Can you tell me what you think will be some of the most important issues facing our country in the next ten years?  
D.B.: "The economy; care for elderly"
4. Can you tell me what you think will be the most important medical breakthroughs likely to take place in the next ten years?  
D.B.: "Brain research; unlocking secrets of the mind"
5. Can you tell me what you think will be some of the most important issues facing our planet in the next ten years?  
D.B.: "Global warming; population explosion; overseas competition"
6. Can you tell me what you think will be the most important changes in technology in the next ten years?  
D.B.: "New technologies for travel and transportation"
7. Can you tell me what you think will be the most important issues facing the environment in the next ten years?  
D.B.: "Threat to weather patterns from industrial pollution"

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