

Priming of Semantic Autobiographical Knowledge: A Case Study of Retrograde Amnesia

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The case of a 36-year-old man who suffers dense retrograde and anterograde amnesia as a result of closed-head injury that caused extensive damage to his left frontal-parietal and right parieto-occipital lobes is described. Patient K.C. has normal intelligence and relatively well-preserved perceptual, linguistic, short-term memory, and reasoning abilities. He possesses some fragmentary general knowledge about his autobiographical past, but he does not remember a single personal event or happening from any time of his life. He has some preserved expert knowledge related to the work he did for 3 years before the onset of amnesia, although he has no personal recollections from that period. Some features of K.C.'s retrograde amnesia can be interpreted in terms of the distinction between episodic and semantic memory, and in terms of the distinction between episodic and semantic autobiographical knowledge. K.C.'s semantic knowledge, but not his episodic knowledge, showed progressive improvement, or priming, in the course of the investigation. © 1988 Academic Press, Inc.

Much of the current knowledge and understanding of the amnesic syndrome is based on the study of anterograde impairment of memory function in brain-damaged patients. Less evidence is available about retrograde amnesia, that is, about retention of information acquired by the patients before the onset of amnesia. The present study makes a modest contribution to redressing the imbalance. It describes the case

This research was supported by a Special Research Program Grant from the Connaught Fund, University of Toronto, and aided by grants from the Natural Sciences and Engineering Research Council of Canada to Endel Tulving and Daniel Schacter, and by grants from the Medical Research Council of Canada and Ontario Mental Health Foundation to Morris Moscovitch. We thank K.C. for his participation in the study, Rick Julian for referring him to us, Janine Law for experimental and logistical assistance, Donald Stuss for consultation and testing of K.C., and Stephen Garnett for the positron emission tomography and analysis. We are especially grateful to the members of K.C.'s family, and to his friends, C.A., R.A., and J.S. for providing us with the vital intelligence without which the study could not have been undertaken. Address correspondence and reprint requests to Endel Tulving, Department of Psychology, University of Toronto, Toronto, Ontario, Canada M5S 1A1.

of a patient who, 5 years after an accident that caused massive closed-head injury, exhibits not only dense anterograde amnesia but also a severe impairment of autobiographical memory that covers his whole life.

Traditionally, studies of retrograde amnesia have concentrated on the extent, severity, and temporal gradient of the impairment (e.g., Albert, Butters, & Levin, 1979; Butters & Albert, 1982; Marslen-Wilson & Teuber, 1975; Mayer-Gross, 1943; Russell & Nathan, 1946; Squire & Slater, 1975; Warrington & Sanders, 1971; Williams & Zangwill, 1952). More recently, interest has shifted to comparisons and contrasts of impaired and preserved memory functions in retrograde amnesia (e.g., Butters & Cermak, 1986; Cermak & O'Connor, 1983; Damasio, Eslinger, Damasio, Van Hoesen, & Cornell, 1985; Goldberg, 1987; Zola-Morgan, Cohen, & Squire, 1983). The present case study, too, was focused on dissociations in the patient's premorbidly acquired knowledge.

CASE HISTORY

K.C. was born in 1951, the first of five children, and delivered during the seventh month of pregnancy. The postnatal period and infancy was uneventful. Developmental milestones were normal. However, at age 18, he received a blow to the head which resulted in admission to the Montreal Neurological Institute and observation for 3 days. He was discharged on phenytoin and phenobarbital and remained on these anticonvulsants for 1 year. He had no seizures, but did not reenter school for 1 year. At age 24, he was involved in a traffic accident, without loss of consciousness, and sustained a fractured mandible. Although painful, neither of the head injuries appeared to have deleterious effects on K.C.'s intellectual functioning. After graduating from high school, he enrolled in a 3-year course in business administration at a community college and graduated at age 25. In the spring of 1978, aged 27 years, he became employed at BE, an engineering and manufacturing company. His job consisted of two activities: driving a delivery and pick-up truck and doing quality control work.

The accident responsible for K.C.'s present condition occurred October 1981, at age 30. Riding his motorcycle home from work, he went off the road. No other vehicles were involved in the accident. He remained unconscious for approximately 72 hr, when a subdural hematoma was removed from the left cranium. He then became stuporous, but responded to commands for about the next 4-5 days. At approximately the seventh post-traumatic day he appeared to recognize his mother. The patient remained in an intensive care unit for 4 weeks. He was transferred to a rehabilitation hospital 6 weeks after the accident and exhibited a severe right hemiplegia. He was discharged home in July 1982, where he has remained in the care of his parents.

Neurological examination on December 12, 1986, revealed an alert, cooperative individual who responded appropriately to all questions. The most striking feature was a marked apathy, flattening of affect, and general indifference to his surroundings. Significant neurological signs included: bilateral anosmia, a right homonymous hemianopia with macular sparing (corrected visual acuity J2 on the right and J8 on the left) and bilateral optic disc pallor. The eye movements were full in the horizontal and vertical planes and no nystagmus was evoked. The left pupil measured 6 mm and responded poorly to light and accommodation whereas the right pupil measured 4 mm and responded more briskly to light and accommodation. The lower cranial nerves were intact.

In the motor system there was ulnar deviation in the right hand, and in the foot lateral deviation of the great toe with marked restriction of movement of the small bones of the foot. The power was intact in upper and lower limbs and there was slight increase in tone at the elbow but no supinator spasticity. His coordination for fine finger movements and finger-nose testing were intact. There was no tremor or voluntary movements noted.

Sensation was intact to pinprick, cold, light touch, and position sense.

There was no sensory inattention elicited and two-point discrimination was equal on both sides of the body. In the finger tips, the threshold for two-point discrimination was approximately 2-3 mm. He was able to discriminate between fine and coarse sandpaper in both hands, and dermatographia was intact bilaterally.

Right hyperreflexia was present in upper and lower limbs and the plantar response was extensor on the right. The palmomental reflex was more pronounced on the right and the pout and snout reflexes were brisk. He exhibited a hemiplegic gait.

Computerized axial tomography, Fig. 1, and magnetic resonance imaging scans of the head were performed. There is mild cerebral and cortical atrophy as evidenced by enlargement of the sulci, ventricles, and cerebellar folia. There is evidence of contusion in the deep white matter of the left frontal-parietal region, and right parieto-occipital region (magnetic resonance scan). There is an infarct in the distribution of the left posterior cerebral artery and a large defect in the left frontal-parietal region sub-adjacent to the previous craniotomy. Positron emission tomography was performed and this revealed that glucose utilization was essentially normal in the regions of the left hemisphere which did not exhibit damage as revealed by the CAT-scan.

K.C. has been observed and tested at our Unit for Memory Disorders since 1983. He participated in a 2-year longitudinal study of memory and cognitive performance of three groups of patients with memory disorders (Schacter, Harbluk, & McLachlan, 1984), as well as in a number of other experiments. For instance, a brief summary description of his state of

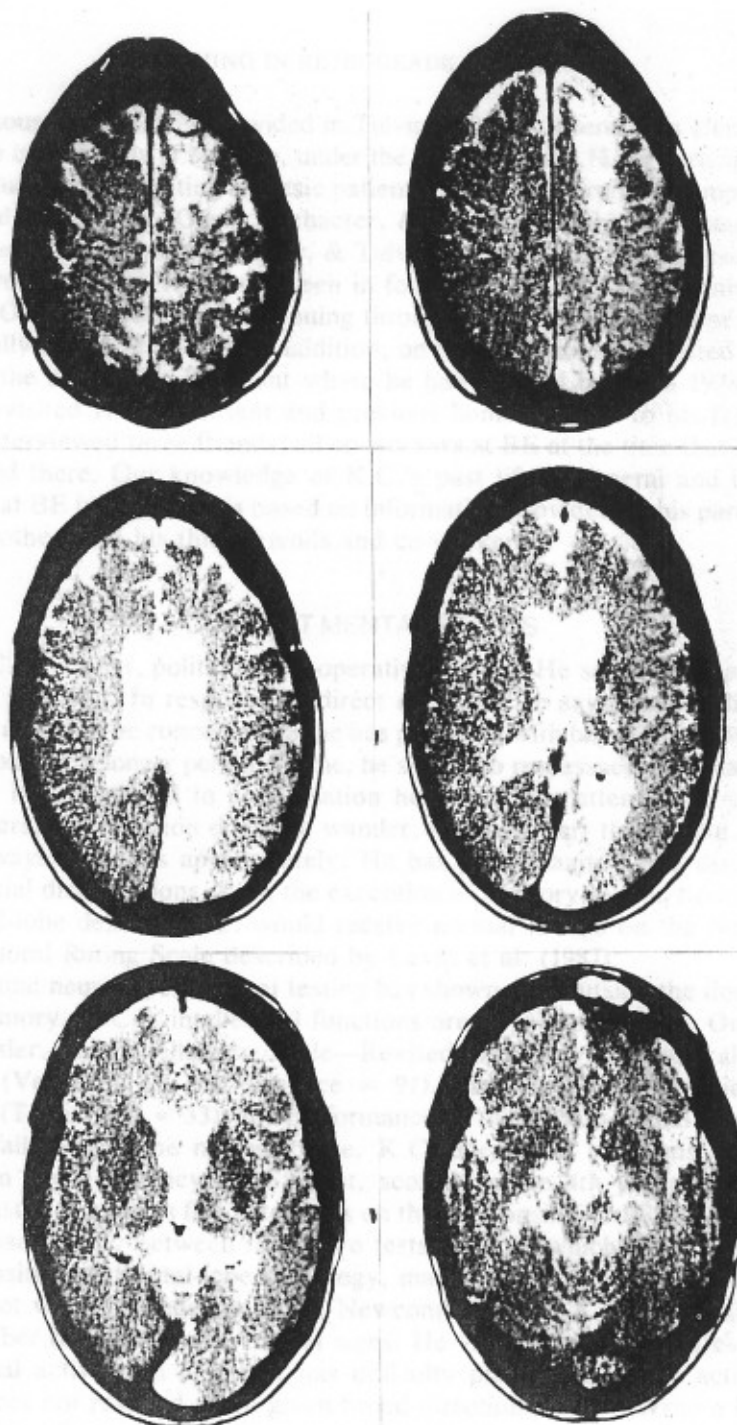


FIG. 1. Computerized tomographic scan images of Patient K.C. The right side of the brain is to the reader's left.

consciousness has been provided in Tulving (1985b), where he is identified by the code initials N.N. Also, under the code initials C.H. he participated in a study demonstrating amnesic patients' ability to learn new computer-related vocabulary (Glisky, Schacter, & Tulving, 1986b) and computer programming (Glisky, Schacter, & Tulving, 1986a). For the purposes of the present study, K.C. was seen in four weekly sessions beginning in early October 1986, and continuing through January 1987. Each session typically lasted 2½ or 3 hr. In addition, on two occasions we visited with K.C. the site of the BE plant where he had worked between 1978 and 1981, visited K.C.'s present and previous homes, talked to his family, and interviewed three friends, all co-workers at BE at the time that K.C. worked there. Our knowledge of K.C.'s past life in general and the 3 years at BE in particular is based on information provided by his parents, his brother, and his three friends and co-workers.

CURRENT MENTAL STATUS

K.C. is a quiet, polite, and cooperative person. He seldom complains about anything. In response to direct questions he says that his life is good, although he concedes that he has problems with his memory. When left alone for a longer period of time, he shows no restlessness or agitation. When he is engaged in conversation he pays close attention to other speakers, his attention does not wander, he stays alert throughout, and he always responds appropriately. He has good manners and displays no social disinhibitions. With the exception of memory-related items and frontal-lobe deficits, K.C. would receive normal ratings on the Neuro-behavioral Rating Scale described by Levin et al. (1987).

Formal neuropsychological testing has shown that outside the domain of memory, K.C.'s intellectual functions are largely preserved. On the Wechsler Adult Intelligence Scale—Revised, he achieved a full scale IQ of 94 (Verbal = 98; Performance = 91). Language comprehension is intact (Token Test = 33), and performance on the Benton Visual Naming Test falls within the normal range. K.C. does have problems on the Benton Word Fluency (FAS) Test, scoring in the 4th percentile. By contrast, he achieves five categories on the Wisconsin Card Sorting Test. The discrepancy between these two tests, both of which are known to be sensitive to frontal-lobe pathology, may appear surprising, although it is not without precedent (e.g., Newcombe, 1969). K.C. does exhibit a number of other classic frontal signs: He virtually never initiates any optional activity on his own, has difficulty planning complex actions, and does not respond when given broad directions (e.g., "Write a brief summary of your life.") He cannot describe his own future, regardless of the time span specified in the question—"this afternoon," "tomorrow," or "next summer" (cf. Ingvar, 1985; Tulving, 1985b). When asked to

describe the state of his mind when he is trying to think about any part of his past or future, he says that it is "blank."

Most of K.C.'s perceptual functions are normal: his final copy of the Rey figure is perfect, his performance on the Hooper Visual Organization Test, which requires perceptual integration of fragments of parts of line-drawn objects, is normal. He readily identifies himself, members of the family, and old friends from photographs and snapshots. Even when shown a recent snapshot of himself, his mother, and one of the authors of this article playing cards at the latter's house, he recognizes all people without difficulty (although he has no idea where or when the snapshot was taken). His ability to imagine familiar objects visually and describe these verbally seems to be normal. However, he does have difficulty with the kind of fine perceptual discrimination tested by the Benton Facial Recognition Test: he receives a score of zero on the test.

K.C.'s thought processes are normal: there are no signs of confusion or disorganization of any kind. He does not confabulate. When he does not know the answer to a question, he says so. When he provides an answer, and is then asked whether he is sure or only guessing, he may respond either way. Once he makes the response, he cannot be easily dissuaded.

K.C. can provide good descriptions of scripted activities (Schank & Abelson, 1977), the kinds of well-organized action sequences in which people frequently engage in their daily life—for instance, going to a restaurant, making a long-distance telephone call, or changing a flat tire. He does all this without any recollection of ever having done any of these things himself.

His short-term memory is essentially normal: His digit span is normal, and he has no difficulty remembering the last two or three items in a meaningful paired-associate list. When he is not distracted, he can hold even a long question in mind for at least up to a minute. His preserved short-term memory capacity is sufficient to play a hand of hearts, or of bridge, without any apparent handicap.

K.C.'s ability to learn new information is very poor. His MQ on the Wechsler Memory Scale is 79.5, which is probably inflated by his good short-term memory. He scores zero on both immediate and delayed tests of the "hard" associates, and also scores zero on delayed story recall and visual reproduction. His performance on Warrington's Recognition Memory test (Warrington, 1984), measured on two different occasions, was at chance for both faces and words: His false-alarm rate was as high as his hit rate.

K.C.'s impairment of memory functions extends to his life before the accident, but it does so selectively. We discuss his pretraumatic autobiographical knowledge next.

PRETRAUMATIC AUTOBIOGRAPHICAL KNOWLEDGE

Two preliminary comments are in order. First, we found some evidence of a gradient of K.C.'s pretraumatic autobiographical knowledge: it is somewhat more intact for earlier than for later acquisitions. Thus, for instance, on a visit to the site, he recognizes the house and the neighborhood where the family lived until K.C. was 9 years old, but he does not recognize the community college he attended for 3 years after high school. Second, some aspects of K.C.'s pretraumatically acquired knowledge showed progressive changes or priming in the course of the study. We describe this priming in greater detail after we have summarized the knowledge that he possessed at the end of our study.

Although we have encountered some gaps in K.C.'s *general knowledge of the world*, by and large it seems to be commensurate with his measured IQ. The state of his *autobiographical knowledge* is different, however, in that it shows both greatly impaired and relatively preserved functions. We describe this knowledge next, under three subheadings: (a) Inability to remember events and their settings, (b) Relatively preserved work-related knowledge, and (c) Priming of semantic knowledge. In this description, when we state that K.C. knows a particular fact, it means that he can answer specific questions affirmatively or appropriately. When we state that he does not know a fact or remember an event, it signifies that, despite repeated and specific attempts to get him to express what he knows or remembers, he answers relevant specific questions negatively, or denies any knowledge or recollection.

Inability to Remember Events and Their Settings

The most striking fact about K.C.'s amnesia is that he cannot recollect a single personal happening or event from his life. He does not remember any incidents from all the years preceding his accident, nor can he remember any of the normally highly memorable things that have happened to him. For instance, he does not remember the accident in which a bale of hay fell on his head at his uncle's farm, necessitating a trip to the Montreal Neurological Institute in 1969 where he stayed for 3 days. He does not remember a serious traffic accident in which he was involved while riding the dune buggy that he had built himself. And he cannot recollect any of the circumstances surrounding the tragic death of his brother by drowning in 1975.

In keeping with this general pattern, K.C. does not remember a single personal happening or incident from the last 3 years before his motorcycle accident, the time during which he worked at BE. We have repeatedly asked him specific questions about some of these episodes, always to no avail. Examples of these events include an altercation in a bar in a small town 2-hours' drive from Toronto as a result of which K.C.'s

shoulder was broken, and after which he rode his motorcycle all the way back to Toronto in what must have been considerable pain, and an accident at BE in which a co-worker drove a fork-lift truck into the back of K.C.'s leg, requiring a trip to the emergency department of the local hospital. K.C. has no recollection of a widely publicized news event in which he was personally involved, the "Mississauga train derailment." In 1979, a freight train carrying deadly chemicals was derailed near K.C.'s home, and 240,000 people in the area were evacuated and stayed away from their homes for 1 week. He also has no recollection of some of the often-repeated personal happenings, such as numerous motorcycle rides with his friend C.A. through the countryside and small towns of Southern Ontario, or visits to the pubs in downtown Toronto with his friends. Specific and elaborated queries directed at these generic events are always answered negatively.

In addition to these profound impairments in remembering events, K.C. also has great difficulties in remembering the settings of events. Thus, for example, his knowledge of the location of the BE plant is vague. He knows the direction in which it is located from his home, but he places it some 8 km closer to his home than it actually is. Furthermore, he does not recognize the outside of the BE plant when he is taken for a visit to the site, nor does he recognize the inside of the plant from photographs. One photograph, for instance, shows a long row of lathes on the factory floor. K.C. walked by them hundreds of times, yet he identifies them as "extruders" and, in the context of other questions having to do with BE, can only "guess" that they may be at BE. He does not remember or know that he worked out of a small office on the factory floor. The office was the only one in an otherwise wide-open space of the factory. When shown a photograph of the office and asked to describe it, he says, "It looks like an office," but he does not perceive it as familiar. As a final example, he usually cannot name any places to which he drove his truck while working for BE, although he made deliveries in Ontario and neighboring states of the United States. Sometimes he makes a few guesses, including wrong ones. When given the name of Romulus, a small town near Detroit to which he drove the truck on many occasions, he claims no familiarity with it.

Relatively Preserved Work-Related Knowledge

In contrast to K.C.'s inability to remember personal events and happenings, and their temporal-spatial settings, his factual knowledge of his past seems to be somewhat better preserved. Following are some examples from his "BE era."

Knowledge of work. K.C. knows that he worked at BE. He knows that his work involved driving a truck and he can describe the color and make of the truck. He can usually also add that he did quality control

on extruder screws. He can produce the names of a number of people who were his friends from high-school days and who also worked at BE. He knows the names of a few other co-workers whom he first met at BE, including that of his closest friend with whom K.C. spent a lot of time together at work as well as after hours.

Technical terms. We tested K.C.'s knowledge of 15 technical terms (e.g., keyway shank, spiral mandrel, pneumatic tailstock, stellite). Eleven of these were terms that should have been known to him, and the remaining 4 were "lures," terms that he could not have known. In each of the four sessions, we presented each of the terms to him auditorily, one at a time, and asked him to make a simple yes/no judgment regarding its familiarity. Then, in a second pass through the list, we asked him to provide a definition for each of the terms. K.C. readily expressed familiarity with all 11 target terms and could provide adequate definitions for 10 of them.

Inspection reports. When K.C. was working at BE, one of his jobs was to perform quality control measurements on extruder screws, a component of one of BE's products, and to report the results by filling in standard two-page forms. We obtained a copy of an actual report, dated 1980, filled in by K.C. in his own handwriting. We showed K.C. the report, in each of the four sessions, asking him for both general and specific information about it. Initially his knowledge was uncertain, but by the third session he correctly described the function and general characteristics of the inspection report. Initially, too, he did not recognize his handwriting on the report, but when we asked him the question in the third session, "Who would have written such a report?" K.C. answered "I might have." When asked why he said that, he responded, "Because these were the things I worked with." He also said that the handwriting looked like his own.

Photographs and drawings of equipment. K.C. had no difficulty in identifying a photograph of an extruder screw and a photograph of another piece of equipment. He also identified and provided correct information about an engineering drawing of an extruder screw. In each of the four test sessions we showed him a color photograph of a large film die, one of the main pieces of equipment used in the process of making blown-film sheeting. We asked him to describe it, what it was and what it was used for. Although initially he denied any knowledge of it, toward the end of the 4-week period he knew the name of the machine, could describe its function, and claimed that he had "worked with them" at BE.

Priming of Semantic Knowledge

A good deal of K.C.'s relatively preserved work-related knowledge that we have just described did not exist at the beginning of our study,

in the sense that he could not respond appropriately to relevant questions. It became accessible to K.C. in the course of the investigation. We refer to the process of such enhanced accessibility as "priming." Priming was typically quite rapid, and its effects were relatively permanent.

When we asked K.C. before the beginning of the 4-week investigation, what he did after he graduated from the community college, he did not know. When asked, "Did you work?" he responded "I think so," but he could not tell what the work was. When told that he had been driving a truck, and asked whether he remembered doing so, he responded negatively. After 4 weeks of intensive questioning him about his "BE era," he knew that he had worked at BE after graduating from the community college, and he knew about driving the truck as well as about his quality-control work with extruder screws.

Similar priming occurred with the names of co-workers at BE. For instance, when in the initial session we asked K.C. whether he knew C.A., his closest co-worker and friend, in whose company he had spent practically every day during a period of some 2 years, he thought about the question for 17 sec before responding, "The name sounds familiar." When asked, "Have you ever worked with him?" he responded, "I think so, yeah!" When asked, "Where?" he responded after a 5-sec pause, "I don't know." But a week later, in the second session, K.C. did not hesitate in answering the questions about C.A.: Yes, he worked with him, and it was at BE.

His knowledge of technical terms also showed priming. The relevant data are summarized in Table 1. The number of target terms that K.C. judged familiar increased from the first session to the maximum possible in the second session, and the number of correct definitions also showed an upward trend. (K.C. missed the definitions of two "easy" items in the fourth session, possibly because he seemed a bit more tired than usual). There was one target item whose definition K.C. could not provide in any of the four sessions. Note that although the number of *lure* terms judged familiar also increased systematically from zero in the first session to the maximum possible in the fourth, the number of correct definitions of these lures remained at zero throughout.

Perhaps the most striking instance of priming was provided by the picture of the film die that we mentioned earlier. When he was shown it at the very beginning of the 4-week study and asked what the pictured object was, he could not provide a positive response of any kind. When he was asked to guess, he said that "It's got something to do with a computer." He had no idea what it was used for, did not know the names of any of the visible parts, could not guess where a machine like it might be located, and claimed that he had never seen the pictured machine himself. As always, we noted his responses without comment or correction.

TABLE 1
PROGRESSIVE CHANGES (PRIMING) IN JUDGED
FAMILIARITY AND KNOWLEDGE OF THE
MEANING OF TECHNICAL TERMS
ACROSS 4 WEEKLY SESSIONS^a

	Sessions			
	1	2	3	4
Familiarity judgments				
Targets	5	11	11	11
Lures	0	1	3	4
Knowledge of meaning				
Targets	7	10	10	8
Lures	0	0	0	0

^a The patient was tested with 11 target terms that he should have known and 4 lure terms that he should not have known. Numbers shown are frequencies of positive responses.

However, only 45 min later, in the same first session, K.C. was shown the photograph of the film die again, and asked the same questions about it. In the meantime he had been tested for his knowledge of technical terms described above. The list of items had included "film die" and "air ring," which is a prominent part of the film die. When, after these interpolated activities, we showed K.C. the photograph of the die again and asked what it was, he responded, after 9 sec, "It is a die," and on further questioning provided a satisfactory description of the function of the machine.

In the second session, K.C. readily identified the film die on the photograph and provided a good description of its function. At that point we showed him another photograph of the same film die, with him standing beside it, adjusting a heat sensor on it. He was visibly amused, but on questioning could provide no idea about what he was doing with the die nor about the occasion or purpose of the photograph. By the fourth session he knew both the die and the fact that he had been working with dies at BE.

DISCUSSION

The most conspicuous fact concerning the state of K.C.'s memory functions is that his amnesia for personal happenings is total and complete. He does not remember any single, extended, or repeated episodes of any kind from any period of his life. As his anterograde amnesia is equally dense, we can say that K.C. possesses no consciously apprehensible

past or, for that matter, future: He seems to live in a "permanent present." Other manifestations of his severely impaired autobiographical knowledge include his inability to recall any details of the setting in which he worked at BE, and his highly schematic and impoverished knowledge he has about himself in relation to BE.

The severity of deficits in K.C.'s knowledge concerning his past activities in their temporal-spatial settings, and the extension of the deficits to his whole life, make his case unique in the extant literature. Other amnesic patients with severe and extensive retrograde amnesia whose cases have been described in some detail (e.g., Andrews, Poser, & Kessler, 1982; Butters & Cermak, 1986; Cermak & O'Connor, 1983; Damasio et al., 1985; Goldberg & Bilder, 1987; Zola-Morgan, et al., 1983) can provide information about *some* specific personal happenings, from *some* period in their past. K.C. cannot describe *any*.

The severe impairment of K.C.'s personal recollections contrasts with his nonpersonal knowledge of the past that is much less impaired even if it is by no means normal. For instance, he can draw an adequate floor plan of the house in which he lived for the first 9 years of his life, although he does not know where his room was located. He can produce the names of the schools he attended; name classmates from a group photograph; mention the names of some of his high-school teachers. He knows that the family owns a summer cottage, he knows its location accurately and can readily find it on a map of Ontario, and he knows that he has spent vacations and weekends there. He knows that he successively owned two motorcycles, as well as a car, together with some of the details of these vehicles; size, make, and color. He knows that he built a dune buggy; that his brother R. drowned; that he has visited and stayed with friends in New Orleans. He knows that he worked at BE, as well as some other places, and he knows the company's products. The expert technical knowledge that he acquired at BE is quite respectable, especially after priming.

Before we attempt to account for K.C.'s memory impairment, we must emphasize that his memory impairment is extensive. It involves remote and recent episodic and semantic memory, although not equally, as we will argue. The constellation of his deficits does not fit neatly into any simple pattern. Nevertheless, some generalizations are possible. Above all, we would like to suggest that K.C. has completely lost certain memory functions, and has deficits of variable severity in others.

Some features of the picture of K.C.'s retrograde amnesia could be accounted for in terms of concepts such as the temporal gradient of retrograde amnesia (cf., Cermak, 1986; Butters & Cermak, 1986; Parkin, 1986). Some other features may reflect the extent or intentionality, or both, of original learning of the information under scrutiny. But these factors cannot account for his complete inability to remember even the

most salient *events* from his life, events that would be highly memorable by normal standards. Nor can these factors account for his complete lack of recollective familiarity with extended or frequently repeated episodes that other participants, who "learned" these happenings presumably under the same conditions as K.C., remember well.

A general characterization of K.C.'s retrograde amnesia that fits certain aspects of the pattern of his performance is based on the distinction between episodic and semantic memory. Episodic memory is concerned with the remembering of personal happenings and experiences that are dated and located in subjective time and space, whereas semantic memory underlies acquisition and retention of publicly verifiable facts of the world.

The distinction between episodic and semantic memory has been described and elaborated elsewhere (Tulving, 1972, 1983, 1985a, 1987). It has been applied to the analysis of phenomena of amnesia in general (e.g., Cermak, 1984; Goldberg, 1987; Kinsbourne, 1987; Kinsbourne & Wood, 1975; Parkin, 1982; Schacter & Tulving, 1982; Shimamura & Squire, 1987; Wood, Ebert, & Kinsbourne, 1982), and to the interpretation of cases of retrograde amnesia in particular (e.g., Butters & Cermak, 1986; Cermak, 1986; Cermak & O'Connor, 1983). There are many features in the profile of K.C.'s memory performance that fit the distinction. His good descriptions of scripts, juxtaposed with his total lack of awareness of whether he himself has ever engaged in any described activities, provides an excellent illustration of the semantic/episodic contrast.

The episodic/semantic distinction also applies to a person's autobiographical knowledge, that is, to the knowledge a person has about himself and his past (Crovitz & Schiffman, 1974; Robinson, 1976; Rubin, 1986). This point has been made by Cermak and his colleagues (Butters & Cermak, 1986; Cermak, 1986; Cermak & O'Connor, 1983), as well as by others (e.g., Hudson, 1986; Parkin, 1986). Both normal people and amnesic patients can answer questions about themselves and their personal past not only by virtue of consciously remembered episodes but also on the basis of their "personal semantic memory," that is, on the basis of their *knowledge of the fact* that certain personal events happened. Thus, for instance, the postencephalitic patient S.S. described by Cermak and O'Connor (1983) can answer questions about his own past and report on public events that took place before his illness, but he does so in the absence of what could be regarded as particular recollections. Cermak (1984) characterized S.S. as lacking episodic but possessing semantic "remote memories." He used two criteria in arriving at this assessment: the patient's lack of knowledge of the *circumstances* surrounding a known autobiographical fact, and the patient's inability to provide any details about, or to *embellish*, any autobiographical anecdote or statement. By these criteria, the autobiographical facts that K.C. can express in response

to specific questions do not represent episodic recollections. His knowledge of such *facts* as his having worked for BE and having driven a truck can be regarded as largely semantic, since he cannot remember the circumstances under which he worked at BE and he cannot embellish the fact that he drove the truck. The semantic autobiographical knowledge that K.C. possesses is akin to the knowledge he has about, say, his father being a lawyer, working at a certain downtown address. His inability to remember any *events* or happenings from any period of his life further underscores the severe impairment of his episodic memory.

It is important to note that K.C. differs from S.S. in that he cannot or does not tell *any* stories or anecdotes about himself. Information about particular past personal happenings is not only totally inaccessible to K.C.'s consciousness, it also does not seem to be a part of his semantic autobiographical knowledge. Therefore, the problem of interpretation arises mainly with respect to the autobiographical knowledge of the generic kind that he can express, exemplified by his statements that he worked at BE and drove the truck.

As K.C.'s thought processes are unimpaired, he is perfectly capable of making appropriate inferences when answering questions about his past, provided that relevant semantic autobiographic knowledge is available. Thus, for instance, when he is asked, "What was the saddest moment in your life?" he answers, "When my brother died." Since he does not *remember* anything about the circumstances surrounding the event of his brother's death, we must assume that the answer to what appears to be an episodic memory question is made on the basis of a deduction or inference from semantic autobiographical knowledge. When concordant semantic information is not available, similar ostensibly episodic-memory questions draw a blank. For instance, K.C. can never answer a question such as, "What is the most interesting book you have ever read?" despite the fact that he was an avid reader of books, because he has access neither to the requisite episodic nor to the relevant semantic information.

If the general line of reasoning we have adopted here is correct—that a person's autobiographical knowledge may be based on episodic information, semantic information, or both—then an important methodological lesson follows: interpretations of findings from studies (e.g., Zola-Morgan et al., 1983), in which amnesic patients' *episodic memory* is tested with procedures such as those proposed by Crovitz and Schiffman (1974) and their derivatives, deserve another look and require more refined analyses than have been customary so far.

Three other patients have been described in the recent literature whose profiles of retrograde amnesia are similar to that of K.C. The postencephalitic patient D.R.B. was characterized by Damasio et al. (1985, p. 255) as having intact perception and memory for generic information while his "memory for the relationship between separate stimuli, their

temporal mark, and their personal, historical aspects as well as separate events or components of events was severely impaired." Another patient, J.V., described by Stuss and Guzman (in press), has lost conscious access to practically all of his past. Since he has little anterograde amnesia, however, he has been able to relearn a number of facts about his past from his wife. J.V. now possesses a good deal of postmorbidity acquired autobiographical knowledge about his premorbid life, but he remembers essentially nothing. A third patient, a 36-year-old man who developed profound retrograde amnesia *without* anterograde amnesia following injury caused by an open skull fracture, has been described by Goldberg and Bilder (1987). This patient has lost all episodic information for some 20 years as well as certain kinds of semantic information. He too has partially relearned his life history, but the autobiographical knowledge thus gained lacks any "sense of authenticity" for him; he always draws "the distinction between what he 'knew' and what he 'had been told' about himself" (Goldberg & Bilder, 1987). These case studies, together with Case S.S. (Cermak & O'Connor, 1983), provide converging evidence for the interpretation of certain aspects of amnesia in terms of episodic and semantic memory.

The interpretation of certain features of K.C.'s retrograde amnesia in terms of the episodic/semantic distinction receives further support from our observations about priming of K.C.'s work-related knowledge. We observed priming for some semantic knowledge but not for episodic knowledge, despite the fact that conditions favorable for its occurrence were present: K.C. was given detailed descriptions of real events from his life in each of the four sessions. He consistently denied any knowledge of, or familiarity with, these happenings. The tentative conclusion suggested by these observations—that in cases of brain-damage like K.C.'s, recollection of personal episodes is difficult, perhaps impossible, to prime—fits well into the hypothesis that K.C.'s episodic autobiographical memory is entirely lost to conscious access whereas his semantic autobiographical knowledge is less impaired.

Three other points concerning priming are also worth noting. First, priming occurred despite the fact that K.C. could never consciously recollect the occasion on which priming occurred; a kind of "retrograde source amnesia" for the knowledge acquired through priming. (For source amnesia in amnesic patients, see Schacter et al., 1984, and Shimamura & Squire, 1987). Second, priming occurred even for some items of information with which K.C. had no prior familiarity. The best example is provided by the distractor items in the "familiarity test" of expert terms, as shown in Table 1. It is important to note that K.C. only claimed familiarity with these terms, and consistently denied any knowledge of their meaning. K.C.'s familiarity with these terms may reflect his repeated encounters with them across the four testing sessions: the absence of

priming of his knowledge of the meaning of the "familiar" terms reflects the absence of appropriate feedback. Third, K.C.'s primed expert knowledge from the BE era has the quality of "free fragments" (Schacter & Tulving, 1982) or "free radicals" (Tulving, 1983) about it. He can express it, albeit somewhat inconsistently, in response to specific queries and cues, but the effects of priming seem to be restricted to highly specific information, exhibiting little integration with other related information.

The brain damage sustained by K.C. is extensive, and so is the impairment of his memory functions. It is difficult, therefore, to relate specific components of one to particular aspects of the other. Thus, we can only speculate that the severe impairment of K.C.'s recollection of personal events and temporal-spatial settings of these events may represent the consequences of the massive damage that he sustained to his frontal lobes, particularly on the left. We base this suggestion on the clinical and experimental findings that lesions to the frontal lobe frequently lead to impaired memory for temporal and spatial information associated with particular events or items (Milner, 1974; Milner, Petrides, & Smith, 1985; Moscovitch, 1982; Petrides & Milner, 1982; Schacter, 1987; Smith & Milner, 1983), even if bilateral frontal damage is only inconsistently associated with a severe global amnesia (Stuss & Benson, 1986). Whether it is the frontal damage alone that accounts for the pattern of memory deficits in K.C. or whether it is that in combination with extensive extrafrontal damage, possibly hippocampal, cannot be determined from the information that we have available.

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