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A SOCIAL–COGNITIVE NEUROSCIENCE ANALYSIS OF THE SELF

Stanley B. Klein, Keith Rozendal, and Leda Cosmides
University of California, Santa Barbara

Over the last several years, researchers have begun to appreciate the ways in which questions of interest to personality and social psychologists can be addressed with neuropyschological case material (e.g., Klein & Kihlstrom, 1998; Klein, Loftus, & Kihlstrom, 1996; Macrae, Bodenhausen, Schloerscheidt, & Milne, 1998). In this paper we show how a neuropsychological approach can contribute to our understanding of the mental representation of self. We first review some of the limitations of studies of self that rely on findings from normal participants, and show how these can be overcome by examining the performance of patients with neuropsychological impairments. We then present the case of patient D.B., who suffered profound amnesia as a result of anoxia following cardiac arrest, as an example of the way in which the study of neuropsychological syndromes can cast important new light on questions concerning the mental representation of self.

In this article we show how questions of interest to personality and social psychologists can be addressed with neuropyschological case material. In particular, we demonstrate the utility of a neuropsychological approach to studying the mental representation of knowledge about the self. We first review limitations inherent in investigations of self that rely on psychological studies conducted on normal—that is, brain-intact—individuals, and argue that these can be overcome by examining the performance of patients with neuropsychological impairments. We then present the case of patient D.B., who suffered profound anterograde and retrograde amnesia as a result of cardiac arrest, as an example of the way in which the study of neuropsychological syn-

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dromes can cast important new light on questions concerning the representation of self in memory.

SELF AND MEMORY

Usually we think of cognition in third–person terms, in terms of how people acquire, represent, store, and retrieve knowledge about the world outside themselves. This is also true for social cognition, which has to do with how we perceive, remember, and think about other people, their behaviors, and the situations in which we encounter them (e.g., Kihlstrom & Cantor, 1984; Wyer & Srull, 1986). At least for humans, however, cognition also turns inward, representing peoples' knowledge about themselves. It is this uniquely human ability—the capacity to experience ourselves as thinking, feeling, wanting, doing beings—that gives rise to psychology in the first place (e.g., Humphrey, 1984; Kihlstrom & Klein, 1994). Indeed, no less an authority than William James (1890) proclaimed the self as the fundamental unit of analysis for a science of mental life, the problem about which everything else revolves.

Yet, for a very long time academic psychology, influenced by arguments from "black–box" behaviorism, largely ignored questions about the mental representation of self. All that began to change, however, in the early–1960s as psychologists came to appreciate the limitations of a pure stimulus–response approach to understanding human nature (for review, see Gardner, 1985), and the self gradually reclaimed its place as a central construct in psychology (Gergen, 1971; Kihlstrom et al., 1988; Kihlstrom & Klein, 1994; Rosenberg, 1979; Vallacher, 1980).

Part of the renewed interest in the self centered on the question of whether the mental representation of self differs from other types of mental representations (for reviews, see Greenwald, 1981; Higgins & Bargh, 1987; Kihlstrom & Cantor, 1984; Kihlstrom & Klein, 1994; Linville & Carlston, 1994). Speculation about the uniqueness of self was fueled by theoretical and experimental work on the role of self–knowledge in information processing. Particularly influential in this regard was Rogers, Kuiper, and Kirker's (1977) demonstration that tasks requiring participants to judge trait adjectives for their personal descriptiveness (e.g., "Does the word kind describe you?") led to better recall than did other types of judgments performed on the same material (e.g., orthographic, semantic; see also, Bower & Gilligan, 1979; Hull & Levy, 1979; Keenan & Baillet, 1980; Klein & Kihlstrom, 1986; Klein & Loftus, 1988; Klein, Lof-

tus, & Burton, 1989; for review, see Symons & Johnson, 1997). Given the recall superiority found for self–referential judgments, it seemed to a number of investigators that the self must have special properties that distinguish it from other structures in memory (e.g., Greenwald, 1981; Greenwald & Pratkanis, 1984; Kendzierski, 1980; Rogers, 1981; Rogers et al., 1977), and explaining this "uniqueness" soon became the dominant focus of research exploring how self–knowledge is represented in memory (for review, see Higgins & Bargh, 1987; Linville & Carlston, 1994).

However, it was not long before studies began to uncover conditions under which self–referent recall failed to exceed that of comparison tasks (e.g., Brown, Keenan, & Potts, 1986; Ferguson, Rule, & Carlson, 1983; Klein & Kihlstrom, 1986; Klein & Loftus, 1988; Maki & McCaul, 1985), leading some to suggest that the memorial effects of self–reference might be explained without attributing special properties to the self (e.g., Higgins & Bargh, 1987; Kihlstrom & Cantor, 1984; Klein & Kihlstrom, 1986; Greenwald & Banaji, 1989).

As often is the case when an initially hot topic proves more complicated and less theoretically fruitful than originally expected, interest in the uniqueness of self gradually subsided and the issue was left unresolved. Part of the reason for this loss in interest was the presence of conflicting findings concerning the memorial superiority of self–referential judgment. But a more fundamental problem was methodological: The experimental techniques used to examine the self lacked the resolution necessary to draw firm conclusions about underlying process and structure. Using procedures borrowed from experimental cognitive psychology, investigations of self–knowledge largely consisted in varying input conditions (stimuli and task instructions) and measuring responses (e.g., recall, recognition, response latency) in an effort to infer the processes intervening between input and output. Unfortunately, as a number of theorists have come to realize, it may not be possible to uniquely specify underlying cognitive processes solely on the basis of stimulus–response relations obtained from the study of normal experimental participants (for discussions, see Anderson 1976, 1978; Barsalou, 1990; Leslie & Thaiss, 1992; Martin, 2000; Shallice, 1988).

As an example, consider again the process of judging traits for self–descriptiveness. How does a person know that he or she possesses some traits but not others? How is this knowledge represented in and retrieved from memory? Two theoretical perspectives on these questions can be found in the literature (for review, see Kihlstrom & Klein, 1994; Klein &

Loftus, 1993). The computational view argues that we determine whether we posses a particular trait by retrieving memories of our trait–relevant behaviors (i.e., exemplars) and computing their similarity to the trait being judged (e.g., Bower & Gilligan, 1979; Keenan, 1983; Locksley & Lenauer, 1981; Smith & Zarate, 1992). The abstraction view, by contrast, proposes that specific behaviors are the source from which trait information is abstracted, but that knowledge of one's traits consists of summary representations that are formed as a result of those abstractions (e.g., Buss & Craik, 1983; Klein & Loftus, 1993; Klein, Loftus, Trafton, & Fuhrman, 1992; Lord, 1993). We decide whether a trait is self–descriptive by accessing summary knowledge of our traits and determining whether the trait in question is among the traits represented in summary form.

While a clear distinction between computational and abstraction models can be made at a conceptual level, distinguishing them empirically is quite difficult (e.g., Barsalou, 1990; Hintzman, 1986; Keenan, 1993; Klein, Loftus, & Kihlstrom, 1996). For example, Klein and Loftus and their colleagues (e.g., Klein & Loftus, 1990, 1993; Klein, Loftus, & Sherman, 1993; Klein, Loftus, Trafton, & Fuhrman, 1992; Schell, Klein, & Babey, 1996; Sherman & Klein, 1994) developed a priming procedure to examine the role played by behavioral memories and trait summaries in trait self–descriptiveness judgments. In a series of studies, they found that participants who made self–descriptiveness judgments about trait words were no faster than participants who performed a control task to then perform a second task that required them to retrieval personal memories in which they exhibited trait–relevant behaviors. They concluded from this that participants made self–descriptiveness judgments by accessing trait summary knowledge without activating behavioral memories. If behavioral memories had been activated during self–descriptiveness judgments, the participants who made those judgments should have had an advantage over participants who performed the control task in the speed with which they subsequently retrieved trait–relevant behavioral memories.

There is, however, a problem with this conclusion. Because participants in Klein and Loftus's studies had access to both summary trait knowledge and the original behavioral memories from which those abstract summaries were derived, it is difficult to rule out interplay between these two potential sources of self–knowledge and therefore difficult to compellingly demonstrate that people use one representation and not another. For example, although participants appeared to

make self–descriptiveness judgments without retrieving trait–relevant behavioral memories, it is possible that such memories were retrieved, but that the procedures used to detect their retrieval were not sufficiently sensitive (for discussion of this possibility, see Keenan, 1993; Klein, Loftus, & Kihlstrom, 1996). Indeed, even when procedures are explicitly designed to discourage participants from retrieving behavioral memories (e.g., by asking participants simply to provide definitions for presented traits; Klein & Loftus, 1993), it still is not possible to guarantee that participants' responses won't be "contaminated" by behavioral recollections (e.g., Keenan, 1993).

Thus, one can never rule out an entire class of models that use computational processes, nor can one rule out an entire class of models that use abstract summary representations, on the basis of data obtained from participants with normal memory function (e.g., Barsalou, 1990). Accordingly, results obtained from cognitive explorations of the self–judgment process have proved less useful in explicating the memorial properties of self than originally expected (e.g., Higgins & Bargh, 1987; Klein et al., 1989).

A SOCIAL NEUROPSYCHOLOGICAL APPROACH TO UNDERSTANDING THE SELF

In a series of papers, Klein and Kihlstrom and colleagues (e.g., Kihlstrom & Klein, in press; Klein, 1999, 2001; Klein & Kihlstrom, 1998; Klein, Chan, & Loftus, 1999; Klein, Cosmides, Costabile, & Mei, in press; Klein & Loftus, 1993; Klein, Loftus, & Kihlstrom, 1996; see also Hirst, 1994; Lieberman, Ochsner, Gilbert, & Schater, 2001; Tulving, 1993) have argued that neuropsychological studies of brain–injured patients can provide insights into the cognitive bases of self–knowledge that are unobtainable from persons with intact neurological function.[1] A neuropsychological approach to studying cognition is predicated on two assumptions: (a) complex cognitive systems (such as self–knowledge) can be decomposed into a number of functionally isolable, but normally interacting, component processes or subsystems (e.g., Fodor, 1983; Gazzaniga, Ivry, & Mangun, 1998; Marr, 1982; Shallice, 1988; Tulving, 1983), and (b) under-

1. Along these lines, Anderson (1978) also proposed that the study of the brain might offer a way to decide issues of internal representation, but questioned whether the technology of his time was up to the task.

standing of complex systems can occur through observation of what happens when different subcomponents break down as a result of brain damage (e.g., Parkin, 1996; Shallice, 1988; Weiskrantz, 1997). Given the automatic and flawless way in which components of a system normally interact, it often is difficult to untangle their respective contributions to any particular task. However, because neuropsychological disorders can be selective—patients exhibit normal or near normal performance in some domains and profound impairments in others (e.g., Caramazza, 1986; Kolb & Whishaw, 1996; Parkin, 1996)—they can provide a window into the operation of a component system in relative isolation, without the influence of other systems (e.g., Hirst, 1994; Martin, 2000). By revealing the differential pattern of impaired and preserved performance, the study of patients with neuropsychological impairment can thus illuminate aspects of a system's function and structure difficult to detect under normal operating conditions (e.g., Shallice, 1988; Tulving, 1983; Weiskrantz, 1997).

Klein, Loftus, and Kihlstrom (1996; see also Klein et al., 1999; Klein, Cosmides, Costabile, & Mei, in press), for example, have been able to examine the utility of a neuropsychological approach to studying the cognitive properties of self–knowledge. They took as their starting assumption the proposition that the self can be conceptualized as a complex knowledge structure subserved by (at least) two neurally and functionally dissociable component systems: Episodic memory and semantic memory (e.g., Kihlstrom et al., 1988; Klein & Loftus, 1993; Klein, Cosmides, Tooby, & Chance, in press; Klein, Loftus, & Kihlstrom, 1996; Klein, Sherman, & Loftus, 1996; for related views, see Craik et al., 1999; Kircher et al., 2000; Lord, 1993; Tulving, 1993). By hypothesis, episodic memory contributes to self–knowledge by enabling a person to become consciously aware of specific events and experiences that occurred in his or her past. In this way, it provides an individual person with a personal narrative and a sense of self as existing through time. Semantic memory, by contrast consists in generic, context–free knowledge, enabling a person to know facts and generalizations about himself or herself (e.g., information about one's psychological traits and dispositions) without having to consciously recollect the specific experiences on which that knowledge is based. With respect to the computational and abstraction models of self–knowledge discussed above, the episodic memory system represents the neurological instantiation of the former, while the semantic memory system reflects the latter.

Klein, Loftus, and Kihlstrom (1996) reasoned that patients suffering amnesia would provide a particularly effective method for examining the respective contributions of episodic and semantic memory to the creation of self–knowledge. This is because amnesic patients often experience highly selective memory loss, typically displaying intact semantic memory with impaired access to episodic memory (e.g., Cermak, 1984; Kinsbourne & Wood, 1975; Moscovitch, Yaschyshyn, Ziegler, & Nadel, 2000; Parkin, 1987; Tulving, 1983, 1995). Therefore, it is possible with amnesic patients to test models of trait self–knowledge with assurance that episodic memory for traits is not involved. If, as hypothesized, different aspects of self knowledge are mediated by different neural systems, then an amnesic patient should be able to know what he or she is like despite being unable to recall the particular experiences from which that knowledge was derived. Thus, by observing the pattern of preserved and impaired self–knowledge accompanying amnesia, and relating it to what is known about the properties of the memory systems assumed to underlie that knowledge, it should be possible to gain insight into the memorial properties of self.

In their study, Klein, Loftus, and Kihlstrom (1996) examined the self–knowledge of amnesic patient W. J., an 18–year old undergraduate who suffered a concussive blow to the head shortly after completing her first quarter in college. Brain scans revealed no neurological abnormalities; but she complained of memory and concentration difficulties, and informal questioning revealed that she appeared to have forgotten much of what had happened in her life during the preceding 6–7 months—a period of time covering approximately her first quarter at college. By contrast, testing revealed that W.J.'s semantic memory was intact. Over the next month, W.J.'s amnesia remitted completely.

To document W.J.'s episodic memory deficit, Klein, Loftus, and Kihlstrom (1996) administered the Galton (1879) memory–cueing procedure popularized by Crovitz (e.g., Crovitz & Shiffman, 1974; see also Robinson, 1976). In this task, participants are read cue words (representing affects, objects, and activities), one at a time, and for each are asked to recall a specific personal event from any time in the past and provide as precise a date as possible for that event. When tested five days after her accident, W.J. showed little memory for personal events from recent years. Four weeks later, her performance had improved considerably and was indistinguishable from that of three neurologically healthy women who served as controls.

Both during her amnesia and after its resolution, W.J. was asked to provide personality ratings describing what she was like during her first term at college. In contrast to the change in her memory performance over the month following her accident, W.J.'s personality ratings of herself at college did not change at all over the same period of time: Her trait ratings made during her amnesic period agreed with those she made afterward. Thus, while she was amnesic, W.J. knew what she had been like in college despite the fact that she couldn't recall any personal experiences or events from her time in college (For related findings, see Bachna, Sieggreen, Cermak, Penk, & O'Connor, 1998; Corkin, 2002; Klein et al., 1999; Klein, Cosmides, Costabile, & Mei, in press; Reinvang & Gjerstad, 1998; Tranel & Damasio, 1993; Tulving, 1993).

Admittedly, it is possible that W.J.'s ratings were based on her continued access to her recollections of personal experiences from high school (or earlier) that were not covered by her amnesia. However, other evidence suggests that accurate self–description can occur even in cases of extreme episodic memory loss covering an entire life. For example, Tulving (1993) found that amnesic patient K.C., who, as a result of a motorcycle accident was unable to consciously bring to mind a single thing he had ever done or experienced, was able to describe his personality with considerable accuracy. Tulving asked K.C. on two occasions to judge a list of trait adjectives for self–descriptiveness. Tulving also asked K.C.'s mother to rate K.C. on the same traits. Tulving's findings revealed that K.C.'s ratings were both reliable (K.C.'s trait self–ratings showed 78% agreement across sessions) and consistent with the way he is perceived by others (there was 73% agreement between K.C.'s and his mother's ratings of K.C.'s traits). Thus, K.C. appears to have reliable and accurate knowledge of his personality without being able to remember any of the specific actions and experiences on which that knowledge was based.

Klein, Loftus, and Kihlstrom (1996; see also Kihlstrom & Klein, 1997; Klein, 1993, Klein, Cosmides, Tooby, & Chance, in press; Klein & Kihlstrom, 1998; Klein, Babey, & Sherman, 1997) interpreted these findings as support for the proposition that examining the ways in which pathologies of memory compromise self–knowledge can shed light on the component cognitive processes mediating that knowledge. The fact that during their amnesia patients W.J. and K.C. both had access to trait abstractions about themselves, but not the particular episodes on which that knowledge was based, was taken as evidence that these two types of

self–knowledge are subserved by two neurally and functionally isolable systems, one of which (episodic memory) had become dysfunctional as a result of brain injury, whereas the other (semantic memory) remained unimpaired (for related views, see Brewer, 1986; Craik et al. 1999; Hirshman & Lanning, 1999; Kircher et al., 2000; Tulving, 1993; Wheeler, Stuss, & Tulving, 1997). These findings suggest that self–knowledge can be understood in terms of the operations of well–known systems of memory, and thus argue against the view that the self has special mnemonic properties that distinguish it from other structures in memory.

GOALS OF THE PRESENT RESEARCH

However, the fact that neurally impaired individuals don't need episodic memory to identify their traits doesn't necessarily mean that they use semantic memory to do so. Demonstrating this would require that, in addition, semantically impaired individuals (e.g., DeRenzi, Liotti, & Nichelli, 1987; Hodges & Patterson, 1997; Markowitsch, Calabrese, Neufeldt, Gehlen, & Durwen, 1999) have a diminished capacity to make trait self–descriptiveness judgments (for discussion, see Klein, Loftus, & Kihlstrom, 1996). Absent this demonstration, the most one can conclude from the available data is that while recollections of one's personal past appear to depend in an important way on the operations of episodic memory, trait self–descriptiveness judgments do not.

In this paper we attempt to address this gap in our understanding of the self–judgment process by presenting the case D.B., an amnesic patient who suffers serious impairments to both episodic and semantic memory. If, as we have argued, trait self–descriptiveness judgments and autobiographical recollections depend on the operation of semantic and episodic memory, respectively, then patient D.B. should show impairments both in his ability to know what he is like as well as his ability to recall specific experiences and events from his life.

CASE STUDY

PATIENT D. B.

D.B. is a 78–year–old, right–handed male with 15 years of education. In November of 1999 he suffered a heart attack while playing basketball. When the paramedics arrived they found D.B. to be in ventricular fibrillation and without pulse. He was given CPR and his pulse returned. By

the time he reached the hospital, he had a blood pressure of 92/54 and a pulse of 86. A diagnosis of cardiac arrest with presumed anoxic encephalopathy was made. Over the next few weeks, his physical condition improved and he was discharged from the hospital into the care of his daughter.

D.B. was referred to the first author (S.B.K.) for neuropsychological evaluation of memory complaints. Although a CT scan administered shortly after his admission to the hospital revealed no sign of acute intercranial abnormality[2], he was disoriented for time and place and experienced great difficulty remembering personal events. Informal questioning and psychological testing (see below) revealed that he was unable to consciously bring to mind a single thing he had done or experienced predating his heart attack. In addition to this dense retrograde amnesia, D.B. also had severe anterograde amnesia, leaving him unable to recall material that had only moments before been present in mind.

D.B.'s semantic knowledge also was affected by his illness, although this impairment was less severe than that affecting his episodic memory. His general level of intelligence appeared to be largely preserved, as was his ability to understand and respond to questions. He knew a variety of general facts about his life, but showed a number of striking gaps in his life story. For example, although he knew where he was born and the name of the high school he attended, he could not recall the names of any friends from his childhood or the year he was born. He also showed spotty knowledge of facts and events in the public domain. For example, although he was able to recount a number of detailed facts about certain historical events (e.g, the Civil War), his knowledge of other historical facts was seriously compromised (e.g., D.B. stated America was discovered in the 1800's by explorers from Great Britain).

CONTROL PARTICIPANTS WITH NO MEMORY LOSS

We also tested two neurologically healthy age–matched (M = 75 years) and education–matched (M = 16 years) controls on the same battery of

2 In a second CT scan, conducted approximately 4 months later, the ventricles and sulci appeared mildly prominent, suggesting some central and peripheral atrophy. Such generalized cerebral atrophy commonly is found in patients who suffer memory impairments following cardiac arrest (for a recent review, see, Grubb et al., 2000).

memory and personality tests that were administered to D.B.In addition, both D.B.'s 48 year–old daughter and an adult child of each of the control participants (*M* age = 46.5 years) completed the personality questionnaire used to test D.B. and control participants

TESTING EPISODIC AND SEMANTIC MEMORY

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 two months after he had suffered his heart attack. All participants were tested individually, and all gave informed consent prior to participating in the study.

ANTEROGRADE MEMORY FUNCTION

A detailed presentation of D.B.'s anterograde memory function is reported in Klein, Loftus, and Kihlstrom (in press). Summarizing those findings, D.B.'s immediate memory, as assessed by the digit span technique (e.g., Weschler, 1981), was in the normal range (6 digits) and comparable to that of age–matched controls (*M* = 6.5 digits, *SD* = .71). His performance on tests of free recall and recognition, by contrast, was severely impaired. On a test of supraspan free recall (e.g., Crowder, 1976) D.B.'s performance fell almost 2.5 standard deviations below that of the controls. Moreover, his recall was limited to the last three items presented from a list; in contrast, the controls showed normal serial position curves, with recall best for items from the beginning and end of a list. D.B.'s recognition memory performance also was seriously compromised. When asked to decide (yes/no) for each item on a list whether it had been presented previously (half of the items had been presented during the learning phase of the study), D.B.'s performance essentially was at chance; he correctly identified 38% of the "old" items and 56% of the new items (Chi Square [1] = 1.25, ns). Based on these findings, Klein, Loftus, and Kihlstrom (in press) concluded D.B.'s anterograde memory for information beyond the span of immediate memory appeared severely compromised regardless of whether assessed by recall or recognition tasks.

RETROGRADE MEMORY FUNCTION

Personal Episodic Memory. To test memory for personal episodes, we used a modified version of the autobiographical memory–cueing task originated by Galton (1879) and subsequently modified by Crovitz (Crovitz & Schiffman, 1974; see also Klein, Loftus, & Kihlstrom, 1996; Robinson, 1986). Participants were told that we were interested in studying memory for autobiographical experiences. They then were 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, one 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

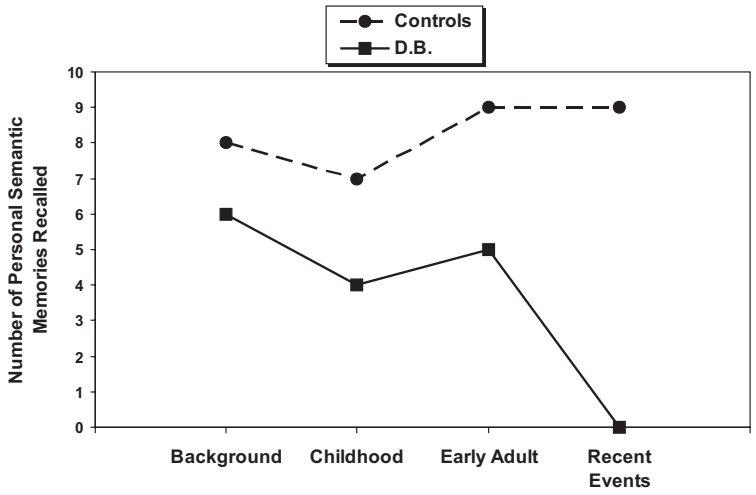

FIGURE 1. Personal semantic memory performance for D.B. and control participants on the modified version of the Autobiographical Memory Inventory.

were judged by family members to be confabulations composed of novel combinations of temporally disjointed fragments from his remote past.

Personal Semantic Memory. To assess participants' semantic knowledge of personal facts, we administered a modified version of the Autobiographical Memory Interview (AMI; e.g., Kopelman, Wilson, & Baddeley, 1989, 1990). Participants were asked to generate information relating to three life periods—childhood, early adult life and recent life. Nine questions requesting various personal facts (e.g., names of friends, teachers, children, addresses, occupations) were generated for each of the three life periods. In addition, participants responded to 9 questions requesting personal background information (e.g., place and date of birth, names of parents, siblings).

Participants were instructed that they would be asked a series of questions requesting factual information about their school days, early adult life and more recent times. All participants received the same set of 36 questions (9 from each of the 3 life periods and 9 background questions) in the following order: (a) background information, (b) childhood, (c) early adult life, and (d) recent life. Participants were read the set of questions, one question at a time. If a participant was unable to answer a

question within 2 min, the trial was terminated and the next question was read. Authenticity of responses was checked against information provided by family members.

The results are shown in Figure 2. In contrast to his almost complete lack of episodic personal knowledge, D.B.'s semantic personal knowledge appeared partially intact (he responded correctly to 42% of the questions on the modified AMI). Nonetheless, his performance was well below the 92% correct level of responding achieved by control participants. As can be seen, D.B.'s performance was inferior to that of control participants at each life period, with the deficit greatest for the most recent time period (this latter finding may reflect the greater vulnerability of recent memories to brain damage in older individuals; for discussion, see Kopelman, 1994). Thus, although D.B.'s semantic personal memory appears better preserved than his episodic personal memory, his performance on the modified AMI still falls far short of that of age–matched, neurologically healthy controls.[3]

Nonpersonal Semantic Memory. To investigate participants' access to nonpersonal semantic knowledge, we selected one task (verbal fluency) from the battery of semantic memory tests used by Wilson and Baddeley (1988), and one task (the semantic version of the Galton–Crovitz memory–cueing test) from the battery compiled by Dalla Barba, Cappelletti, Signorini, and Denes (1997) . In the verbal fluency task, participants were required to generate as many items as possible from each of four semantic categories: Animals, fruits, furniture, and girls' names. Participants were asked to respond verbally and were allowed 1 min per category. The results of this test revealed that D.B.'s ability to generate category exemplars (M = 8.75 items per min) was more than two standard deviations below the range established by control participants (M = 14.12; SD = 2.30).

In the semantic version of the Galton–Crovitz memory–cueing test, participants were presented with six cue words (discovery, war, king, revolution, assassination, president). For each word they were asked to produce a detailed account of a specific historical event which occurred

3. D.B. also received an episodic version of the modified AMI in which he was required to retrieve personal experiences and events pertaining to the same three life periods covered by the semantic version of the test (childhood, early adult, and recent life). He was unable to successfully recall a single episode or event from his life from any of the periods tested.

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 richly 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 only 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 and 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."

Taken together, tests of D.B.'s anterograde and retrograde memory performance document a profound impairment in his ability to recollect personal events that transpired both prior to and following his illness. In comparison to the profound deficit he exhibits in episodic memory function, his semantic memory is somewhat better preserved. Even here, however, his performance falls well below that of neurologically healthy age–matched controls. It is against this background of pervasive neuropsychological impairment that we turn to an examination of his ability to know what he is like.

TESTS OF TRAIT SELF–KNOWLEDGE

The key question for the present research is whether D.B. can have intact self–knowledge despite impaired access to both the episodic and semantic memories on which that knowledge presumably is based. To answer this question, we asked D.B. and control participants on two occasions to complete a personality trait questionnaire. The questionnaire consisted of 60 trait adjectives selected from norms provided by Kirby and Gardner (1972) and Anderson (1968). The adjectives chosen were close to the norm means on the dimensions of meaningfulness and familiarity and spanned the range of social desirability.

The questionnaire consisted of four sheets of paper with 15 traits per sheet. Beside each trait word were four choices: not at all, somewhat, quite a bit, and definitely. Participants were instructed to indi-

cate, by circling the appropriate choice, the extent to which each trait described how they viewed themselves. Their children also completed the questionnaire, indicating for each trait how well it described their parent.

A second session was conducted one week later. D.B. and the two control participants were again given the personality questionnaire and asked, for each trait, to indicate how well it described them.

Reliability and Accuracy of Trait Self–Knowledge. D.B.'s trait ratings showed good consistency across testings: The Pearson product–moment correlation coefficient between ratings produced in the first and second session was significant ($r = .69$, $p < .05$) and comparable to that for the control participants ($r = .74$). Moreover, the correlation between D.B.'s ratings of himself and his daughter's ratings of him was significant ($r = .64$, $p < .05$) and virtually identical to that obtained from control parent–child pairs ($r = .62$). These results indicate that D.B.'s impressions of himself were at least as reliable and accurate (with child's ratings serving as the criterion) as those of age–matched, non–amnesic controls. In other words, it appears that D.B.'s impaired access to episodic and semantic memory did not greatly affect access to his trait self–knowledge.

It is possible, however, that D.B.'s ratings agreed over sessions because he simply endorsed socially desirable traits and rejected socially undesirable traits on both trials (e.g., Edwards, 1970; Klein, Loftus, & Kihlstrom, 1996). Although the strong positive correlation between D.B. and his daughter argues against this explanation (e.g., McCrae, 1982; Wiggins, 1973), it is possible that trait social desirability also is responsible for agreement between the ratings of parent and child.

To examine this possibility, we correlated D.B.'s self–ratings with the ratings made by the control participant children of their parents. If social desirability is the driving force behind the parent–child correlations we found, we would expect the correlation between D.B. and the children of control participants to be comparable to that between D.B. and his own child. This clearly was not the case: The correlation between D.B.'s self–ratings and ratings of him provided by his child ($r = .64$) was more

4. Note that for control parents, the correlations between ratings of child across sessions were considerably higher than ratings of self across sessions. One possible reason for this is that people tend to perceive less stability over time in their own traits than in those of other persons (e.g., Allen & Potkay, 1981; Sand, 1990; Sande, Goethals, & Radloff, 1988). Accordingly, peoples' self–judgments should show less consistency over time than do their judgments of others.

than twice that between D.B. and children of the control participants (Mean $r = .30$). This suggests that the observed agreement between D.B. and his child was not based purely on social desirability.

An item–by–item analysis of D.B..'s trait ratings provides additional support for this conclusion. Of the 60 trait ratings made by D.B. during the first rating session, 14 traits with socially undesirable features (e.g., prejudiced, sad, ungrateful) were endorsed as either somewhat or quite a bit self–descriptive (ratings from the second session produced comparable findings).

Self vs. Social Trait Knowledge. An important question is whether D.B.'s ability to know what he is like despite pervasive cognitive impairments reflects the selective preservation of self–knowledge, or rather reflects a more general immunity of social knowledge to amnesic insult. In support of the latter possibility, a few studies have reported that amnesic individuals maintain an ability to access knowledge of the traits and characteristics of other persons despite difficulty remembering experiences and events pertaining to those persons (e.g., Johnson, Kim, & Risse, 1985; McCarthy & Warrington, 1992; Tranel & Damasio, 1993). Perhaps, then, D.B.'s intact trait self–knowledge is a special case of a more general phenomenon of preserved knowledge of social entities in the face of widespread cognitive dysfunction.

To address this question, we asked D.B. and control participants on two occasions (separated by one week) to rate their children on the same 60–item personality trait questionnaire described above. We also had the children rate themselves on the questionnaire and compared those ratings with ratings of the child provided by parent. If D.B.'s preserved self–knowledge is a specific instance of a more general sparing of social knowledge, then his knowledge of a well–known other (his daughter) should be preserved as well.

Contrary to this expectation, the correlation between D.B.'s ratings of his daughter and her self–ratings was not reliable ($r = .23$, $p > .10$), and was less than half that between control parents' ratings of their child and the child's self–ratings ($r = .61$). In addition, the correlation between D.B.'s ratings of his daughter across testing sessions, although reliable (rs $= .58$, $p < .05$), was considerably below that demonstrated by control participants ($r = .90$).[4]

Together, these findings demonstrate that when the target is a well–known other (i.e., child), D.B.'s performance suffers in comparison to that of control participants. We thus conclude that the preserved

self–knowledge demonstrated by D.B. is not simply a manifestation of preserved social knowledge; rather, it reflects something specific to the self. D.B.'s preserved trait conception of self implies the existence of intact neural machinery that support such knowledge.

DISCUSSION

As philosophers and psychologists have become increasingly interested in the biological substrates of mental life, cognitive science has evolved into cognitive neuroscience (e.g., Gazzaniga, 1995; Shallice, 1988). One of the most exciting features of this approach has been the use of data and conceptual tools derived from the study of patients with neuropsychological syndromes to address questions about normal mental function. For example, studies of visual imagery in brain–damaged patients have suggested that visual perception and visuomotor control are mediated by different systems and thus not identical (e.g., Milner & Goodale, 1995; Otto–de Haart, Carey, & Milne, 1999; Weiskrantz, 1997). Similarly, studies of patients suffering amnesia reveal a dissociation between episodic and semantic memory and thus suggest the existence of two distinct systems (e.g., Cermak, 1984; Schacter & Tulving, 1994; Tulving, 1995). To date, however, social and personality psychology theorists seldom have considered neuropsychological case material (for review, see Klein & Kihlstrom, 1998).

In this paper we show how neuropsychological evidence can provide new solutions to old problems and afford new theoretical insights for personality and social psychologists as well (for discussions, see Kihlstrom & Klein, in press; Klein & Kihlstrom, 1998).We began with a simple question, but one of fundamental importance to theorists seeking to understand human social cognition—how are we able to know what we are like? (e.g., Humphrey, 1984, 1986; James, 1890; Klein & Loftus, 1993; Parker, Mitchell, & Boccia, 1994). Two broad classes of cognitive models have been proposed to answer this question: Models based on computation and those based on abstraction (for review, see Klein & Loftus, 1993). Computational models posit that self–knowledge is represented in specific events and behaviors involving the self. According to this view, a person decides whether a characteristic is self–descriptive by consulting a library of personal memories and computing an answer from whatever episodes are activated. By contrast, abstraction models

argue that self–knowledge consists in summary representations that have been abstracted from events and behaviors involving the self.One knows things about oneself (e.g., "that I am friendly") by accessing a database of previously computed abstract summary representations.

Unfortunately, deciding between these models has been a formidable challenge. One reason involves what has been called the "contamination"problem (e.g., Martin, 2000): Despite an investigator's best efforts to isolate for study the effects of a particular process on performance of an experimental task, complete isolation is never guaranteed when neurologically healthy individuals serve as participants. For example, because normal participants have access to both exemplar–based and abstraction–based judgment procedures, it is difficult to rule out the interplay between these two processes in performance of self–judgment tasks, and therefore to distinguish between computational and abstraction explanations of the self–judgment process.

Cognitive neuroscience, however, offers a way around the "contamination" problem. It does so by requiring that cognitive models be informed and constrained by knowledge of the neural systems presumed to underlie the processes they purport to explain. Consideration of the function and structure of the human brain provides important constraints on theory construction, enabling a theorist to use neural plausibility as a criterion for deciding among rival positions.

This is the approach we have taken in much of our recent work on the memorial properties of self (e.g., Klein, 2001; Klein et al., 1999; Klein, Cosmides, Costabile, & Mei, in press; Klein, Loftus, & Kihlstrom, 1996). By first mapping the computational and abstraction models of self–knowledge onto well–understood neural systems (episodic and semantic memory), and then examining conditions in which one or both of these systems were impaired, we have been able to separate out the respective contributions of episodic and semantic memory to the creation and utilization of self–knowledge.

In the present paper, we report the case of patient D.B., who was diagnosed with hypoxic brain damage following a heart attack.As a consequence, he suffered a profound amnesia affecting his both his episodic and semantic memory. 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 serious difficulty remembering events and experiences from his past and accessing general facts about both the world and himself.

These findings provided a backdrop against which to evaluate D.B.'s preserved and impaired knowledge about self. If self–knowledge is decomposable into episodic and semantic components (e.g., Craik et al., 1999; Kircher et al., 2000; Klein, 2001; Lord, 1993; Tulving, 1993), and if these component systems both have been compromised by neurological dysfunction, it follows that D.B. should differ in an important way from previously studied patients, each of whom suffered selective loss of episodic memory (e.g., Klein, Loftus, & Kihlstrom, 1996; Tulving, 1993): In addition to adversely affecting his recollection of specific events and experiences from his life, D.B.'s neurological damage should also compromise his ability to know what he is like.

Contrary to this expectation, we found that despite serious impairment of both episodic and semantic memory, D.B. showed highly reliable and accurate knowledge of his personality traits. Indeed, on every analysis of trait self–knowledge we conducted, D.B. performed at a level equal to that of age–matched, neurologically healthy controls. This finding is particularly surprising in light of the fact that on other measures of semantic personal knowledge (e.g., the modified AMI), D.B.'s performance was impaired.

An additional perspective on the question of preserved and impaired self–knowledge is provided by a more subjective analysis of D.B.'s memory—his emotional responses to memory assessment. With one exception, D.B. found memory testing cognitively taxing and emotionally draining. On a number of occasions he became so distressed over his inability to answer questions that testing had to be interrupted to allow him time to compose himself. The one dramatic exception was the test of trait self–knowledge. Despite the difficult nature of this test—it required 60 separate responses to 60 different trait words—he seemed to genuinely enjoy the testing session, occasionally offering unsolicited commentary on his reasons for making a particular rating.[5] It was as though the trait self–judgment process had tapped into an island of lucidity in a sea of cognitive turmoil.

5. D.B.'s commentary consisted entirely of personal generalizations about the trait in question (e.g., "I always try to be considerate to others"). At no point did he provide episodic recollections of behavior in which he (or anyone else) manifested the trait.

IS THERE SOMETHING SPECIAL ABOUT SELF–KNOWLEDGE AFTER ALL?

It thus would seem that D.B.'s knowledge of what he is like escaped unscathed from the ravages brought on by generalized neurological dysfunction affecting both episodic and semantic memory. The fact that D.B. has accurate and detailed knowledge about his personality despite impairment to both the episodic and semantic components of self–knowledge seems to suggest that other types of memory contribute to this aspect of his self.

However, it must be acknowledged that in comparison to his profound episodic amnesia, D.B.'s semantic memory impairment was less pervasive: Although he had serious difficulty on some tests of semantic memory (e.g., the modified AMI and verbal fluency tasks), his general knowledge of word meanings and world events were relatively intact (e.g., the semantic memory–cueing task; though even here his performance fell below that of neurologically healthy controls). This pattern of impaired and preserved aspects of semantic memory is consistent with the idea that semantic memory can be fractionated into different components, each of which can be damaged independently (e.g., Caramazza & Shelton, 1998; Hodges & Patterson, 1997; Mackenzie Ross & Hodges, 1997; Warrington & Shallice, 1984). From this perspective, D.B.'s normal performance on the trait self–knowledge questionnaire can be interpreted as reflecting the operation of a specialized subsystem within semantic memory that represents knowledge about people and was not compromised by his cortical damage. Support for such a view is found in a recent paper by Mackenzie Ross and Hodges (1997), which presented evidence suggesting that semantic knowledge of people may be stored and accessed independently from other types of semantic knowledge (see also McCarthy & Warrington, 1992).

There are several aspects of our data, however, that are inconsistent with this proposal. First, D.B.'s semantic knowledge of his own life history was far from normal: On a test requiring knowledge of personal facts from his past (the modified AMI) he consistently scored well–below that of the controls. Second, his knowledge of his daughter's personality traits (i.e., the daughter trait–rating questionnaire) was severely compromised by his illness. Thus, on two tests requiring access to semantic knowledge about people (both self and other), D.B.'s performance was seriously impaired. By contrast, his performance on a task

requiring access to knowledge of what he is like was indistinguishable from that of control participants.

The idea that awareness of what one is like may be functionally independent of both episodic and semantic memory receives additional support from the study of patients suffering from the clinical condition commonly referred to as Alzheimer's Dementia. In the later stages of the disease, patients experience catastrophic impairments of both episodic and semantic memory, accompanied by a host of related cognitive deficits, including severe declines in language, reasoning, judgment, and spatial and temporal orientation (e.g., Beatty, English, & Ross, 1997; Dorrego et al., 1999; Hodges & Patterson, 1997; Kazuki et al., 2000; Nebes, 1989; Sagar, Cohen, Sullivan, Corkin, & Growdon, 1988; for review, see Brandt & Rich, 1995). Yet, despite pervasive and general cognitive dysfunction, recent investigations reveal that an awareness of what one is like is surprisingly well–preserved in these patients (e.g, Downs, 1997; Sabat & Collins, 1999; Small, Geldart, Gutman, & Clarke Scott, 1998; Tappen, Williams, Fishman, & Touhy, 1999). Echoing these findings, a recent review of the literature on brain damage and awareness of self by Feinberg (2001) has shown that one's sense of personal identity—who one is and what one is like—is almost invariably preserved despite massive neural and cognitive dysfunction (see also Eakins, 1999; Klein, 2001). Such results highlight, in dramatic fashion, the possibility that at least some of the systems supporting self–knowledge are functionally independent of semantic and episodic memory.

The possibility that D.B.'s preserved self–knowledge reflects the operations of a specialized subsystem within semantic memory clearly cannot be ruled out by our findings. However, when all the evidence is considered, it leaves the strong impression that D.B.'s preserved capacity to judge what he is like cannot easily be reduced to, or explained in terms of, what we know about the operations of either semantic or episodic memory.Rather, it seems that trait self–knowledge may be functionally independent of these systems, maintaining its integrity despite episodic and semantic breakdown. There may, after all, be something special about self–knowledge.

WHAT IS THE SELF?

The phenomenology is compelling: Each of us has the experience of a unitary self, an "I" that chooses, remembers, thinks, and feels. Yet it has

been notoriously difficult to provide a cognitive account of the self. The evidence from D.B. and other neuropsychological case histories (e.g., Klein, Loftus, & Kihlstrom, 1996; Klein et al., 1999; Tulving, 1993) suggests that this might be because we have been looking in the wrong place. Instead of looking for a single mechanism that can be identified as a self, perhaps we should be breaking the problem down into parts, and studying each component separately before asking how they interact with one another (e.g., Neisser, 1988).

Neuropsychological studies of D.B and others suggest that this seemingly unitary self may actually be composed of several different, functionally isolable (though normally interacting) systems (Klein, 2001; Klein, Cosmides, Tooby, & Chance, in press):

1. Episodic memories of one's own life (damaged in D.B.);
2. Representations of one's own personality traits (normal in D.B.);
3. Knowledge of facts about one's own life (moderately impaired in D.B.)
4. An experience of continuity through time: The "I" experienced now is connected to the "I" experienced at earlier points in time (disrupted in some severe cases of amnesia; e.g., Klein, Loftus, & Kihlstrom, in press; Tulving, 1985).
5. A sense of personal agency and ownership: The belief — or experience — that "I" (agency) am the cause of "my own" (ownership) thoughts and actions (present in D.B., but impaired in disorders such as autism and schizophrenia; e.g., Frith, 1992; Gallagher, 2000; Hobson, 1993; Klein, 2001);
6. The ability to self–reflect, that is, to form metarepresentations (e.g., German &Leslie, 2000; Leslie, 1987; Klein, 2001; Rosenthal, 1986) where the agent is the self, and make inferences on the basis of them. The data format of a metarepresentation (e.g., Leslie, 1987) allowing self–reflection of this kind would be [*Agent*: "I"]–[*Propositional Attitude*: "thought"]–[*Proposition*: "that X"] (e.g., "I thought that I would be afraid of the dog"). The ability to represent one's own mental states appears to be intact in D.B., but is impaired in autism (e.g., Baron–Cohen, 1989; Carruthers, 1996) and possibly schizophrenia (Frith, 1992).

Are each of these six components truly separate? Perhaps not. A mechanism that produces one of these outcomes may also produce others. For example, the ability to metarepresent one's own mental states may be necessary to have a sense of personal agency and ownership of thoughts, goals, plans, and actions (Frith, 1992; for discussion see Cosmides &

Tooby, 2000).If so, then the outcomes specified in five and six may be reducible to—or explicable in terms of—a single piece of cognitive machinery.

In other cases, one component of the self (e.g., episodic memories) may require the operation of another piece of self–relevant machinery (e.g., metarepresentional machinery), yet have additional properties such that the operation of one cannot be explained entirely by invoking the operations of the other. For example, episodic memories may be stored in metarepresentations ([Agent:"I"]–[Propositional Attitude: "remember"]–[Proposition: "that I saw, smelled, did, (etc) X"]; e.g., Gennaro, 1996; Perner, 1991; Cosmides & Tooby, 2000; Klein et al., 1999), such that damage to the ability to manufacture or retain agent source tags causes impairment in episodic memory (Cosmides & Tooby, 2000; for a review of the evidence that disorders of metarepresentation, such as autism and schizophrenia, impair episodic memory, see Klein, 2001). Yet many amnesics appear to have intact metarepresentational machinery, despite an inability to retrieve episodic memories — suggesting that there is a specialized archive in which episodic memories are stored (e.g., Klein, Cosmides, Tooby, & Chance, in press). On this account, the episodic memory system requires metarepresentational abilities to function properly, but it has other (proprietary) components as well.

Our point is this: To understand what it means, cognitively, to have a "self", divide and conquer may be the best research strategy, and the fractionation provided by neuropsychological data may provide the best database. Although the corpus of relevant neuropsychological cases is still small, it already suggests that "the self" is actually composed of a number of functionally independent systems (e.g., Klein, 2001; Klein, Cosmides, Tooby, & Chance, in press; Neisser, 1988). By developing a careful model of each, one can eventually put the pieces together. Detailed, computationally explicit models of each piece will allow one to discover which (apparently separate) components are actually the outputs of a single mechanism; when one component of the self requires another component to operate properly, without being reducible to that component; and when two components of the self co–exist and jointly contribute to mental life, without requiring one another to operate. Paradoxically, a research strategy that assumes the self is divided may be the fastest way to learn how the parts come together to create the unitary self of our phenomenal experience.

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