Published in final edited form as:

J Clin Exp Neuropsychol. 2008 November ; 30(8): 931–945. doi:10.1080/13803390801894681.

Successful life outcome and management of real-world memory demands despite profound anterograde amnesia

Melissa C. Duff¹, Tracey Wszalek², Daniel Tranel¹, and Neal J. Cohen³

¹ Department of Neurology, Division of Cognitive Neuroscience, University of Iowa College of Medicine

² Biomedical Imaging Center, University of Illinois

³ Beckman Institute, University of Illinois at Urbana-Champaign

Abstract

We describe the case of Angie, a 50 year-old woman with profound amnesia (General Memory Index = 49, Full Scale IQ = 126) following a closed head injury in 1985. This case is unique in comparison to other cases reported in the literature in that, despite the severity of her amnesia, she has developed remarkable real-world life abilities, shows impressive self awareness and insight into the impairment and sparing of various functional memory abilities, and exhibits ongoing maturation of her identity and sense of self following amnesia. The case provides insights into the interaction of different memory and cognitive systems in handling real-world memory demands, and has implications for rehabilitation and for successful life outcome after amnesia.

Amnesia refers to a deficit in memory that can be at the same time dense and yet circumscribed. The cognitive impairment shows specificity *to* and specificity *within* the domain of memory (Cohen, 1984; Cohen & Eichenbaum, 1993; Eichenbaum & Cohen, 2001; Squire, 1992). Individuals with amnesia characteristically exhibit a severe impairment of learning and memory affecting the formation of new enduring declarative memories (anterograde amnesia), as well as loss of declarative memory acquired for some period prior to the onset of brain damage (retrograde amnesia). Yet, they can exhibit preserved intelligence and reasoning abilities, attention, remote memory, and skill acquisition or procedural memory (e.g., Cohen & Banich, 2003; Cohen & Squire, 1980; Parkin & Leng, 1993; Tranel, Damasio, & Damasio, 2000).

Numerous neurological conditions may result in amnesia, including ruptured aneurysm of the anterior communicating artery (Alexander & Freedman, 1984; Damasio, Graff-Radford, Eslinger, Damasio, & Kassell, 1985), anoxia (Rempel-Clower, Zola, Squire, & Amaral, 1996; Zola-Morgan, Squire, & Amaral, 1986), cerebrovascular accidents (De Renzi, Zambolin, & Crisi, 1987; Ver der Werf, Witter, Uylings, & Jolles, 2000), herpes simplex encephalitis (HSE) (Cermak & O'Conner, 1983; Damasio, Eslinger, Damasio, Van Hoesen & Cornell, 1985; Wilson, Baddeley, & Kapur, 1995), and Wernicke-Korsakoff syndrome (Butters & Cermak, 1986; O'Conner, Butters, Miliotis et al., 1992). Although all these etiologies of amnesia share at least some memory impairments in common, they differ substantially in the full range of neuropathological findings, neuropsychological presentation, and clinical implications. Most contemporary cognitive neuroscience investigations of amnesia have focused on the specific contribution of medial temporal lobe (MTL) structures, and in particular

the hippocampus, to various patterns of mnemonic ability and impairment (e.g., Gabrieli, 1998). More clinically oriented treatments of amnesia, concerned with the impact and consequences of memory impairments for patients and their families, have focused on rehabilitative techniques to restore and compensate for lost function and on the management and psychosocial aspects of living and coping with memory impairments (Tate, 2002; Wilson, 1999; Wilson, 2002).

Memory impairments are also common following closed head injury (CHI), although CHI frequently results in diffuse brain damage and a wider range of cognitive impairments that extend beyond the domain of memory. While the hippocampus and other MTL structures may be affected following CHI, a pattern of damage that results in a selective memory deficit is considered rare (Auerbach, 1986). The case we present here is unique for several reasons including the selectivity and severity of her memory impairment secondary to a CHI.

Although amnesia is characterized as being specific to the domain of memory, it is clear that memory impairments can negatively impact the effective operation of other cognitive domains and produce deleterious effects on various aspects of everyday life. Memory impairments are considered to be among the most handicapping of cognitive deficits, often preventing or hindering positive academic, vocational, and social outcomes, and such impairments cause considerable stress to individuals with brain injury and their families (Wilson, 2002). Yet, individuals with amnesia can display considerable variability in their emotional and psychosocial response or outcome following amnesia and in their ability to handle everyday memory demands while living with amnesia (Tate, 2002; Wilson, 1999). Thus, the study of amnesia can illuminate the role of memory in real-world cognition. For those individuals with profound memory impairments such as H.M. (Corkin, 1984), S.S. (O'Conner, Cermack, & Seidman, 1995), Clive (Wilson & Wearing, 1995) and Boswell (Damasio, Tranel, & Damasio, 1989), reports of everyday real-world abilities and on the functional outcome following amnesia uniformly paint a picture of impoverished social networks and interpersonal relationships, limited or no vocational opportunities, and considerable dependence on family or institutional care for emotional and practical support following the onset of the amnesia. Reading about these cases, in fact, leaves one with the impression that such an outcome is typical and expected. The case we present here causes us to question whether this typical outcome is obligatory.

We report the case of Angie (a pseudonym), a profoundly amnesic woman whose case is unique compared to other cases in the literature in terms of the remarkable real-world life abilities she retains despite the severity of her amnesia, and in the way her identity and sense of self have continued to develop following the onset of her amnesia. This case raises the bar for what we once thought possible with respect to functional outcome following amnesia, and provides insights into the interaction of procedural memory systems and other cognitive systems in handling real-world memory demands.

CASE REPORT

Prior to the onset of her amnesia, Angie was living independently in her own home, engaged to be married, and employed as a special education teacher while working on a doctorate in education. In 1985, at the age of 29, she experienced an allergic reaction to an influenza vaccine while driving a motor vehicle and collided with a utility pole sustaining a closed head injury. The CHI resulted in severe anterograde amnesia and right-sided hemiparesis of the upper and lower extremities affecting her motoric speed and gait. Once medically stable, her parents--embarrassed by her physical and cognitive disability--removed her from the hospital, effectively denying her access to treatment, and rented an apartment where she lived with an untrained dog and, for a short period of time, relied extensively on a network of dedicated

friends for assistance with basic activities of daily living (e.g., paying bills, grocery shopping). A year later, Angie attempted to return to work as a special education teacher, but could not learn the names of the students or keep track of their various academic levels and educational plans. During this time, her relationship with her fiancé deteriorated and they did not marry and the friends who were initially so helpful after the injury, slowly stopped visiting. Angie has no contact with any of these individuals today.

By the time Angie came to our attention in 1999, she had accomplished a great deal of success and independence in her everyday life including moving to a new town, graduate school studies, a significant work history as a project manager, she married and helped raise three stepchildren, and she had established and maintained several close friendships. She demonstrated a keen sense of self-awareness and insight into her deficits that extended beyond simply being able to state that she had a memory impairment. She had the ability to state specifically which situations were more challenging as a result of her memory impairment, analyze the cognitive demands of a given task, and formulate a plan to compensate for the memory impairment. In fact, she compensates so fully that few people outside of those very close to her and those of us who test her are aware of her memory impairment. All of these accomplishments were achieved without formal rehabilitation.

In 1999, fourteen years after Angie's head injury, neuroimaging was performed to assess the extent of her brain damage. Anatomical analysis (reported previously in Ryan and Cohen, 2004), revealed shearing lesions of white matter tracts, producing circumscribed lesions distributed diffusely around white matter areas that were denser closer to the center of the brain. There were marked lesions in the pyramidal tracts, presumably accounting for her motor weakness of the upper and lower extremities on the right side. White matter lesions were also observed both in the temporal stem region containing the white matter pathways running between medial and more lateral temporal structures, and in the more inferior pathways to and from the hippocampal region in the forebrain. The structure and volume of the hippocampal region itself did not appear to be abnormal. The shearing of the white matter tracts is consistent with the etiology of a CHI and there is not evidence of a significant anoxic event (i.e., bilateral hippocampal atrophy was not observed). Given the severity of the observed memory impairment, however, we would not anticipate normal hippocampal functioning even in the presence of a structurally intact hippocampus. With respect to the possible neural underpinnings of her memory impairment, the most parsimonious explanation is that the white matter lesions disrupt critical pathways to and from the hippocampus. This account would be consistent with cases in the literature of anterograde amnesia following fornix (e.g., D'Esposito, Verfaellie, Alexander, & Katz, 1995) and basal forebrain (e.g., Morris, Bowers, Chatterjee, & Heilman, 1992) lesions in the context of a structurally intact hippocampus. It remains possible that higher-resolution imaging studies of the hippocampus and related MTL structures than were available to us at the time of our initial scanning might reveal subtler signs of damage, but Angie's claustrophobia has made it impossible to obtain further scans.

In 2000, we began formal neuropsychological testing and an extensive qualitative assessment and documentation of Angie's performance in her everyday life to better understand the factors that may account for her extraordinary outcome. Neuropsychological testing and a series of work and home observations took place between 2000 and 2004. When testing began, Angie was 45 years old and had 23 years of education. Informed consent was given, which was approved by the Human Subjects Committee of the University of Illinois.

Neuropsychological Assessment

General Intellectual Functioning—The Wechsler Adult Intelligence Scale-III (Wechsler, 1997a) was administered to obtain a general measure of intellectual functioning. The age-corrected scaled scores, index scores, and overall IQ scores are presented in Table 1. Verbal,

Performance, and Full Scale IQ scores were 118, 130, and 126, respectively, which are within the high average to superior range and are commensurate with her educational attainment. The Verbal Comprehension and Perceptual Organization Indexes were 124 and 130, respectively, which are in the superior and very superior range. The Processing Speed Index was 99, or the average range, while her Working Memory Index was 80, or the low average range.

Standardized Tests of Memory—Overall, Angie is profoundly impaired on standardized tests of memory. The Wechsler Memory Scale-III (Wechsler, 1997b) was administered to obtain a measure of memory function. The age-corrected scaled scores and index scores are displayed in Table 2. Angie's General Memory Index was 49. These data demonstrate a profound memory impairment, with a 77 point differential between Full Scale IQ and General Memory Index. To put this in context, the 77-point disparity is of a larger magnitude than many other "gold standard" cases in the literature such as H.M. who has a 46-point disparity (Schmolck, Kensinger, Corkin, & Squire, 2002). Her index scores for auditory immediate, visual immediate, auditory delayed, visual delayed, auditory recognition delayed, and working memory were between 71 and 65, which are borderline to extremely impaired scores.

A comment on Angie's working memory ability is in order here. Her performance on working memory tasks is variable (WAIS-III WMI scaled score = 80 or low average; WMS-III WMI scaled score = 63 or extremely low) and in some cases below expectations (e.g., WAIS-III digit span and L-N sequencing subtests). We do not believe, however, that Angie has an impairment in working memory for a couple of reasons. First, consistent with her real-world abilities, Angie demonstrates intact performance on other tasks of working memory (WAIS-III Arithmetic scaled score = 12 or high average), on tasks with obvious working memory demands such as the Wisconsin Card Sorting task (see below), and more generally on all formal and informal assessments of laboratory and real-world executive abilities, widely believed to tax working memory. Second, in our experience administering these tests to Angie, observing and communicating with her in numerous challenging and potentially distracting environments (see below), and in contrast to other patients we have seen with working memory deficits, she is not confused, not disoriented, and remains attentive and task-oriented in all of our interactions with her. Thus, we are reluctant to place too much emphasis on her performance on the subset of neuropsychological measures on which she (only) sometimes scores poorly.

Episodic Memory

The Rey Complex Figure Test was administered to assess visuospatial memory. Although Angie accurately copied the figure (36/36), she was unable to reproduce any aspects of the figure after a 30-minute delay. When asked to reproduce the figure from memory, she stated that she had no memory of seeing any figure earlier in the session. When encouraged to draw any figure that came to mind, she drew a figure eight.

The Rey Auditory Verbal Learning Test was administered to assess verbal learning and memory. After the fifth presentation of the 15-item word list, she was only able to recall 3 words and could not recall any words after a 30 minute delay. Following the third trial she said, "If we have to do this until I remember all of them we will be here forever, it will never happen."

On the logical memory (prose recall) passages of the WMS-III, her scaled scores were 7 on the immediate recall and 3 on the delayed recall. On the verbal paired associate learning subtest of the WMS-III, she scored 0 on both the immediate and delayed recall, scaled scores 3 and 4, respectively.

In addition to these formal standardized tests of declarative memory, we have documented Angie's impaired performance on a number of experimental tasks tapping into declarative memory. For example, she fails to exhibit long-term memory for relations among items in a

scene using implicit eye-movement measures (Ryan & Cohen, 2000), and fails to learn 12 semantically unrelated word pairs (word-word paired associate learning) in a series of 24 trials over two days (Duff, Hengst, Tranel, & Cohen, 2006).

Semantic Memory

Angie's remote semantic memory is intact (high average to superior) as measured by the Vocabulary, Similarities, and Information subtests of the WAIS-III. Knowledge of English vocabulary entering the lexicon from 1955 to 1989 was also intact (94/94) (Verfaellie, Reiss, & Roth, 1995). Angie's ability to recognize and name famous landmarks (Tranel, Enekwechi, & Manzel, 2005) and famous faces (Tranel, 2006) was assessed. Out of 69 natural (e.g., "Old Faithful") and artifactual (e.g., "U.S. Capitol) landmarks from around the world, she recognized 48 landmarks as being familiar and correctly named 45, or 93.7%. For 3 landmarks she said they were familiar but incorrectly named them and said that 21 were not familiar. This pattern of performance in the normal range for non-brain damaged subjects. Out of 155 famous faces, Angie recognized 66ⁱ faces and correctly named 60, or 90.9%. For 4 faces she said they were familiar but was unable to produce a name and said that 89 were not familiar. Taken together, these findings are indicative of intact remote semantic memory and naming ability.

Angie's performance on these neuropsychological tests are interesting, as well, in providing a hint of how she uses world knowledge to guide her successfully through the world (a point to which we will return in a subsequent section). For example, when shown a picture of Newt Gingrich, she stated that the picture was not familiar, but that he was a politician. When asked to provide any additional information, she said that she had never seen him before, "but only politicians get their pictures taken with flags."

Autobiographical Memory

Autobiographical memory was assessed on the Iowa Autobiographical Memory Questionnaire (IAMQ) (Jones, Grabowski, & Tranel, 1998). The questionnaire examines episodic and semantic memories from various phases of ones' life including early childhood and adolescence (0–18 years of age), young adulthood (19–39 years of age), middle adulthood (40–59 years of age), late adulthood (60+), and recent life (past year). Performance is scored as a percentage of correct responses that can be corroborated by a family member or friend. Reported here are the data from childhood/adolescence, young adulthood (covering the period of her head injury), and recent life (past year). In comparison to data from the IAMQ on healthy comparison participants (Tranel & Jones, 2006) Angie's memory performance shows a temporal gradient. Her autobiographical memory for her childhood and adolescence does not differ from a non-brain damaged population. She can provide detailed and vivid information regarding early childhood memories, addresses of childhood homes, and information about other children in her school and neighborhood. In contrast, her memories for her young adulthood, and more so for her recent past, are impaired (See Table 3). Within the young adulthood time period, which spans Angie's 1985 head injury, her memories for events prior to the accident are intact (e.g., her address, information about college, her work as a teacher, names of children she taught) while she is unable to provide information for many events after 1985 (e.g., date and location of her wedding, date and location of her father's death, name of grocery store, home address). Her memory for recent events, within the past year, was quite

ⁱWhile Angie did not recognize as many famous faces as many healthy and other brain injured participants, her performance and the nature of her correct responses are not indicative of semantic memory impairments. Rather, a more reasonable explanation is that in addition to being amnesic for 15 years, her knowledge of movies, television, and sporting events was premorbidly impoverished. In our experience with the famous faces test, in both healthy and brain injured participants, we have found that performance depends critically on their history and frequency of watching television and the like. This is consistent with her self-report that she has never been an avid watcher of television or movies and that there is not a response bias towards successful naming of famous faces that were famous before the onset of her amnesia and those more recently famous.

impaired (e.g., she was unable to accurately recall where or with whom she spent the previous Thanksgiving or Christmas).

Executive Functioning—The Wisconsin Card Sorting Test (Grant & Berg, 1993), the Controlled Oral Word Association subtest from the Multilingual Aphasia Battery (Benton, Hamsher, & Sivan, 1994), the Trailmaking Test (Reitan & Wolfson, 1985), the Stroop Color and Word Test (Golden, 1978), and the Behavioral Assessment of Dysexecutive Syndrome battery (Wilson, Alderman, Burgess, Emslie, & Evans, 1996) were administered to assess Angie's executive functioning abilities. The results from these various tests are presented in Table 4. Performances on all of these tests were at least average with performance on some tests falling into the superior range.

Perception—Performance on several standardized perceptual tests indicated intact visuospatial and visuo-perceptual abilities. Angie performed within the normal range on the Benton Judgment of Line Orientation Test (26/30, 57%ile) and the Facial Recognition Test (47/54, 61%ile) (Benton, Siven, Hamsher, Verney, & Spreen, 1994).

Speech and Language—Performances on the Boston Naming Test (59/60) (Kaplan, Goodglass, & Weintraub, 1983) and the Token Test (44/44) from the Multilingual Aphasia Battery (Benton, Hamsher, & Sivan, 1994) were intact. Angie's speech was fluent, free of paraphasias, clearly articulated, and prosodic. Her comprehension of conversational speech was intact.

Mood—Angie completed the Beck Depression Inventory-II (Beck, 1996) and consistent with her clinical presentation and self-report, there was no evidence of depression (BDI-II = 0). She also completed the Satisfaction with Life Rating Form (Diener, Emmons, Larsen, & Griffin, 1985), which asks five questions to globally assess life satisfaction (e.g., "In most ways my life is close to my ideal.") using a 7-point scale (7 = strongly agree). Angie indicated satisfaction with her life on all the questions (29/35), which is well above the mean of 16.2 reported of nearly 900 individuals with traumatic brain injury living in the community a median of 7 years post injury (Sokol, Heinemann, Bode, Shin, & Van de Venter, 1999).

Behavior and General Observations—Persons who interact with Angie are invariably impressed by how "normal" she seems; i.e., how little memory impairment is evident during ordinary, routine interactions. She is particularly skilled at reading the social cues that people display, many of which are quite subtle. Although she has been working with the same examiners for years, she is unable to recognize them when she comes in for testing and will walk right by them if they do not engage her or make eye contact with her. However, she is constantly searching her environment for context or cues that will allow her to make appropriate choices. If an examiner looks at her expectantly, smiling and maintaining eye contact, she will walk over to them. There is a sense of control and presence that she exhibits in the testing sessions and in her interactions. She never appears disoriented or confused and she does not repeatedly ask questions in a circular manner. Instead, in order to gain control of her environment or in interactions, she frequently initiates conversations, providing only general comments about herself. Consistent with intact working memory abilities, she can follow the thread of a conversation providing regular enough interjections and new information to both keep the conversation going and to keep her partner talking.

Although she agreed to participate in a research program investigating individuals with memory impairment, Angie was initially quite guarded and did not want to expose her deficits during the neuropsychological testing. She was interested in her performance during these sessions, particularly on the memory tests, asking if we considered her performance to be normal or how her performance compared with that of others. She was always cooperative and

compliant during the testing sessions. Consistent with her habitual efforts to conceal her memory impairment in everyday situations, and her ability to assess the memory demands of our various tests, she would playfully try to get out of performing tasks related to her memory impairment, stating with a sly smile, “I don’t need to do that one. I don’t have a memory problem”. In contrast to her upbeat and confident demeanor during sessions dedicated to non-memory tasks, when asked to perform a task that she deemed beyond her memory capacities, she became deflated, upset, and eventually, resigned. She found the memory testing frustrating and could become agitated when pushed to give a response. Over time, however, Angie became less guarded and developed rapport with the two female authors (M.D., T.W.). As a result, she was willing to discuss her situation in more detail, eventually allowing us to conduct the qualitative assessment of her daily routines and strategies at home and work.

QUALITATIVE ASSESSMENT OF EVERYDAY ABILITIES AND ROUTINES

Despite the severity of her memory impairment, which prevents Angie from consciously recollecting and recalling the events of her daily life, she has managed to create a meaningful and productive life without the benefit of rehabilitation. After completing the neuropsychological testing which revealed a selective and severe anterograde declarative memory impairment, we were even more struck by her real-world accomplishments and set out to complete the qualitative home and work assessment to better understand how she successfully manages the memory demands of her everyday life.

Elliott (1990) noted that an inevitable consequence of living with amnesia is the need to simplify and routinize one’s life to minimize failures. It is this ability especially that distinguishes Angie from many other cases in the literature, and was the subject of the qualitative assessment of her everyday abilities and routines. Angie can introspect into the nature of her deficits, analyze the cognitive challenges of a task and generate solutions to many of the problems encountered by individuals living with amnesia that are commensurate with her abilities and appropriate for the demands of the task. In implementing these solutions, she reduces the complexity of a given task by breaking it into a series of smaller, more manageable tasks, which allow her to monitor and exercise control over her environment. These strategies have made it possible for her to manage a home (e.g., shopping, cleaning, money management, meal preparations), raise her three step-children (e.g., managing the family schedule to track school, sporting, and church activities for each child), do the bookkeeping for the family farm, work full-time outside of her home, and more recently oversee the practical, legal, and financial task of placing her mother in a long-term care facility in another state. At both work and home, Angie has skillfully reconstructed her memory for daily events and routines of her life to be externally visible and accessible.

Home

Many of the individuals with amnesia with whom we have worked or who have participated in our research programs, report that they find it difficult to mark the passage of time. For Angie, as one example, this meant losing track of time in the shower. Not being able to remember if she had completed the cycle of all the tasks to do in the shower, Angie would repeat them over and over spending upwards of an hour in the shower. As she became aware of this, she wrote down everything she needed to do each morning in the shower, had it laminated and brought it into the shower. She moved a clothespin down the list as each task was performed. When the clothespin reached the end of the list she knew that she was done. Likewise, in order to keep track of all the household chores, Angie assigned each chore to a given day (e.g., Saturdays are for yard work, Sundays are for house cleaning, Monday evenings are for laundry, and so on).

Angie's husband reported that for years she had the contents of all the kitchen cabinets and drawers labeled on the outside with sticky notes so that she could quickly put away new items from the grocery store or put the clean dishes back in their assigned spot so that she could find them again. When Angie and her husband moved into a new house, the kitchen was organized so that all of the cabinets and drawers were in the exact same location as they were organized at the old house. Through years of experience of using these particular organizational systems, she no longer requires the list in the shower or the sticky notes in the kitchen.

Many of the individuals we have worked with have stopped cooking, reporting that it is too difficult to remember where to find the various ingredients and cooking utensils necessary to make a meal in a timely fashion. Others state that even when they can locate everything, they cannot remember which steps they completed and often will add a given ingredient multiple times. Angie enjoys cooking and has created a system that allows her to prepare the family meals. She organized and labeled each shelf in her kitchen pantry by item (e.g., a labeled row for canned green beans, a labeled row for canned mushroom soup, a labeled row for dried canned onions). Because each row on each shelf is labeled, Angie can quickly generate a shopping list by looking for empty rows. Next to each labeled row of food in the pantry is a stack of recipes that Angie routinely prepares and that include that particular ingredient. These recipes are also cross-referenced. For example, if she wanted to prepare a green bean casserole, she would find that recipe beside the row of canned green beans, the row of canned mushroom soup, and the row of dried canned onions.

When asked outside of the context of her home how she manages her home and is able to keep track of the shopping, the chores, and the children, she can not produce even one of the above examples. She provides responses that are appropriate but lack the personal detail and complexity of her strategies ("I keep lists"; "I write it down in my calendar").

Work

For many individuals living with amnesia, the extent and severity of their memory impairments preclude returning to their premorbid employment setting and significantly limit the range of other vocational opportunities available to them. This scenario is frequently made worse by a lack of insight into the memory impairment resulting in individuals setting unrealistic expectations and creating return to work situations that are doomed to fail. It is at these times that the psychosocial and emotional consequences of adjusting to amnesia are most evident and many amnesic individuals struggle with anxiety and depression.

Although Angie could not return to her previous occupation given the severity of her memory impairments and the specific demands of the job, she has made realistic choices about employment that are consistent with her keen insight and her ability to assess the memory demands of a task. Following the onset of amnesia and her unsuccessful attempt to return to her career as a special education teacher, Angie has had a long employment history taking positions that utilize her intact remote knowledge of education and test development that she acquired in college and graduate school. She has worked as a research assistant for an organization conducting research on reading assessment in children and as a project manager for a company that develops tests and assessment literature.

As a project manager, Angie is in charge of overseeing and tracking the progress of various projects, supervising other staff, and meeting the deadlines associated with the projects. Angie created routines that enhanced her job performance, handling each of the projects she manages in the same way and thereby taking advantage of procedural memory. The level of organization and external memory devices she employs is remarkable. Angie creates a hierarchy of smaller tasks that all projects require for completion and assigns each project a color to track progress and meet deadlines. Like her organization at home, Angie builds in redundancies in her systems

to prevent mistakes or situations where she might be vulnerable to failure or having her memory impairment revealed. This hierarchy of tasks and the color coding system are recorded on a folder that each project is assigned and then again on a calendar that sits on her desk. It is only when she opens these folders that she knows in any detail what her job is or what tasks require her attention. Angie also keeps a personal log book where she again records many of the notes that exist on the calendar and in the folders. It is here, though, that she can keep track of her own thoughts and progress about the projects that are not accessible to the other employees. Angie cannot, however, report or describe what she does at work in any detail. When asked about her employment she will say that she is a project manager. When asked what that means or what a typical day at work is like, she replies, "I manage projects." She is unable to provide any detail about any of the projects she works on, the necessary steps to perform her job, the names or information about the people with whom she works, or her annual wage.

Angie also keeps copious notes regarding phone conversations and there are two copies of these notes: one to be filed in the appropriate folder (i.e., for a given project or for a given person) and another copy that was easily accessible on her desk. She has an assistant who takes all incoming calls and then tells Angie who is on the phone. Angie can then search her notes and quickly review them before taking the call. These notes serve as her memory for previous contacts with others, informing her of the relevant issues and some detail about the topics of the previous conversation. The result is a sense of normalcy for both her and the person she is communicating with as she can make reference to some specific piece of information (e.g., "How was your trip home to see your mom?").

Both over the phone and when speaking to Angie in person, one is struck by her pragmatic and conversational skills. Angie is an engaging conversationalist. Unlike many other amnesic patients we have worked with she is an equal and active participant contributing to the conversation and initiating new topics. These skills are used to her advantage in concealing her impairment and in diverting attention and topics away from her. At work in a staff meeting, Angie opens up a meeting by asking everyone around the table to give a brief report about the status of their project, frequently asking for their opinions on various subjects. While they talk, she takes notes and then reiterates their statements. For her, these are overt strategies for compensating for her memory impairment. For her employees, these actions are interpreted as a leadership style where she is very open to and provides validation of their ideas and suggestions.

Rigidity of Strategies

Clearly, Angie's success lies in her ability to create routines and procedures to handle many of the real-world memory demands in her life. Once mastered, these routines are performed with ease although with little flexibility in their execution. For example, Angie has developed a set of reliable (albeit inflexible) driving routes that allow her to drive to work, a friend's house, the grocery store, and the academic site where we have tested her. However, she only drives to each of these places from home. She refuses, for example, to drive from the grocery store to work. Additionally, if there is road construction or a detour on one of these routes, she will turn around and go home. This behavior is consistent with Angie going to great lengths not to expose or fail due to her memory impairment. Given her intelligence, intact executive abilities, and problem solving skills, one might predict that she could find novel routes or be more flexible in the implementation of her strategies and routines.

For Angie, however, the risk of deviating from those procedures that are consistently successful is simply too great, because it could expose her memory impairment but also because of the underlying fear of being or appearing lost and confused. For example, when Angie comes to see us for testing, she will park in the handicap spot, which accommodates her physical impairment. She also uses this as a strategy to remember where she has parked. (Another

strategy she uses is to look for a blue car in the handicapped spot. She decided to only buy blue cars after the onset of her amnesia. She also keeps her license plate number written down in her calendar). In contrast to her usual confident stride and demeanor upon entering the building to meet the examiner, on the occasions when there is another car in the handicapped spot Angie seems upset and worried, frequently looking back at the parking lot as she walks to the entrance of the building and lamenting that she was unable to park there.

In addition to the emotional energy expended when she is forced to deviate from the rigid execution of these strategies, another downside is the inordinate amount of time and physical energy in completing these tasks. For example, although she has a series of routine procedures in her repertoire (e.g., driving routes, tracking progress at work), despite significant overlap among them and despite her exceptional organizational skills, she avoids concatenating the different destinations (e.g., will not drive to supermarket on her way home from work) or tasks for each projects (e.g., works serially on each task although each requires that same steps).

Interpersonal Relationships

Despite the deterioration of the relationship with her fiancé following her head injury, and by her report the loss of many friends who knew her prior to her head injury (include those that helped her immediately following her injury), Angie has developed and maintained several meaningful interpersonal relationships since the onset of her amnesia. She has married and developed several close female friends with whom she goes shopping, out to lunch, and travels. Angie prides herself on being a “good judge of character” which she reports relying on more so now because of her memory impairment. During the observations that took place at her work site, she revealed that she liked and trusted many of her colleagues. Of one female colleague, however, she stated, “You have to watch out for her. She’ll stab you in the back,” yet could not provide any evidence for why she felt that way.

Comparison to Other Cases

The neuropsychological profile presented here is not what distinguishes Angie from other cases of anterograde amnesia in the literature (although her amnesia is remarkably severe and remarkably circumscribed). Instead, it is her success in navigating and managing the real-world memory demands of her environment and the success she has enjoyed in creating and participating in a rich social and emotional life that makes her so unique. We believe Angie’s functional outcome is the most impressive of any case in the literature of someone with such a selective and severe amnesia. This is particularly evident when compared to the poor real-world outcome of cases such as Boswell, Clive, H.M., and S.S. Of course, one obvious difference between Angie and these other cases is the extent of brain damage. Angie’s damage is quite modest, affecting only the white matter tracks leaving the structure of the hippocampus and other MTL structures intact. She does not have the extensive bilateral MTL and limbic system damage and frontal lobe involvement documented in these other cases and perhaps it is not reasonable to expect that they should show such a good functional outcome.

A case that does provide an informative comparison is that of Jay, reported by Wilson (1999). At the age of 20, Jay had surgery for a left posterior cerebral artery aneurysm that resulted in a lesion largely restricted to the hippocampal area, that caused a selective anterograde amnesia (Full Scale IQ =121; WMS-R GMI= 69). Like Angie, Jay demonstrated considerable achievements in using compensatory techniques and strategies (many of which are remarkably similar to those developed independently by Angie although some were more intrusive – e.g., alarms), independent living, and employment. Like Angie, Jay’s brain injury occurred at a young age, he has superior intellectual abilities, and intact executive functions and other cognitive abilities. Wilson and Watson (1996) have identified these variables to be among those that are highly predictive of successful compensation and independence.

Jay, however, did not experience as positive an outcome as Angie. Several critical differences exist that may account for this difference. Jay's use of compensatory techniques was developed and supported by extensive in-patient and outpatient rehabilitation, counseling and the long-term vigilance and dedication of family members. In contrast, Angie achieved her level of independence without the benefit of formal rehabilitation or long-term support by family and friends, relying on her own creativity and ingenuity to develop novel solutions for the everyday memory demands in her environment. As mentioned previously, Angie had friends who helped her considerably after her injury, but the strategies discussed here (those deployed during her marriage and at work) were developed and refined long after these friendships dissolved.

Jay struggled to adjust to the emotional and social consequences of living with amnesia: "He has in the past gone through times when he felt very low and sad about his life. He was expecting to be a lawyer with a good income and he has instead become a craftsman with just enough to live on" (Wilson, 1999). As noted by Wilson (1999) however, Jay's self esteem has increased through his active involvement in a local self-help and support group for memory impaired individuals, and he has appeared on television and radio programs about amnesia. For Angie, the social and emotional consequences of amnesia have not been as severe. She has attained all of the life milestones she had imagined for herself: she enjoys a mutually satisfying marriage, has raised children, has developed new close and enduring friendships, and has maintained a skilled and independent employment history in the field in which she was trained. In addition, she does not identify with being "cognitively impaired" or "amnesic," and she does not attend support groups.

While Jay and Angie both have IQs in the superior range, Angie has considerably more education (23 years) than Jay (and many of the other gold standard amnesia cases). Premorbid intelligence and educational attainment have both been linked to models of cognitive reserve and are thought to offer protective benefits following brain damage or disease (Stern, 2002). Although we are not entirely sure of its significance, we are struck by the fact that so many well-known cases of amnesia are men (e.g., H.M., S.S., Clive, Boswell). There are cases of anterograde amnesia in women, of course (e.g., Tate, 2002), but we are intrigued nonetheless by the possible contributions of sex (biological) and gender (social and cultural) to the positive outcome reported here. Finally, as mentioned previous and elaborated on below, Angie has minimal MTL damage; much less so than Jay and the other well known cases in the literature. While Angie's minimal damage did not produce a less severe memory impairment, the lack of wide spread limbic system and frontal lobe damage surely contributed to the observed outcome.

DISCUSSION

We report the case of Angie, a woman who sustained a head injury at the age of 29 and has a profound anterograde amnesia, and who is unique in terms of the real-world life abilities she retains despite the severity of her amnesia. The consistency and regularity of the successful routines she deploys in her daily life and the rigidity of their execution suggest that her real-world abilities are largely supported by structures outside of the medial temporal lobe and by non-declarative or procedural memory systems. That successful interventions can be designed to take advantage of intact procedural memory to establish positive behavioral routines for everyday activities for individuals with severe impairments is well established (Wilson, 1999; Ylvisaker & Feeney, 1998). Yet, it is the interaction among procedural memory and other cognitive systems (e.g., executive functions) in handling the real-world memory demands that is the most illuminating. Angie is able to introspect into the nature of her deficits, generate and implement strategies to exercise control over her environment, and then monitor the success of the routines in those controlled environments. Indeed, Wilson (1999) suggests a pure memory deficit with intact executive and other cognitive abilities typically results in better outcomes.

The current case also highlights the contribution of motivation and social and emotional factors related to real-world functioning, a growing area of interest in understanding the consequences of living with amnesia (e.g., O'Conner et al., 1995; Tate, 2002). In a review of the psychosocial consequences of memory impairments in amnesic patients H.M. and S.S., both of whom have extensive limbic system damage including amygdala damage, Tate (2002) points to a lessening of emotions and motivations and posits that these blunted or shallow emotional responses may not be limited to an individual's own altered life circumstances but may also extend to their interpersonal relationships. O'Conner et al. (1995) suggest that in addition to the neuroanatomical damage affecting emotion-related areas in the case of S.S., profound amnesia, resulting in an inability to integrate new experiences and knowledge, may precipitate "emotional stagnation" or prevent emotional maturation. In contrast, Angie, who has a memory impairment every bit as severe as H.M. and S.S. on standardized assessments of memory, but who does not have extensive MTL damage, has created a rich social and emotional life. Based on our interactions with her, and reports from her husband and friends, her affect and emotional responses appear fully normal and appropriate. These findings lead us to believe that more extensive brain damage affecting emotion-related areas (e.g., amygdala, insula, somatosensory cortices) may contribute to the poor social and emotional functioning and outcome frequently observed in many patients with amnesia, more so than severity of the memory impairment per se.

Tate (2002) also points to the distinction between a lack of *insight* (roughly akin to anosognosia) and a lack of *concern* (roughly akin to anosodiaphoria) underling the observed blunted emotional responses in many cases of amnesia and extensive MTL damage. Perhaps more so than any other case we are aware of, in addition to a keen sense of insight, Angie is deeply concerned about concealing her memory impairment. She is also extraordinarily motivated and dedicated to presenting herself so that her life appears, on the surface at least, to be unaffected by her amnesia. Although we will never know the impact of effectively being abandoned by her family because they were ashamed of her impairments or the issues that might have contributed to her motivation to conceal her memory impairment, we consider them to be among the relevant contextual or environmental factors in her case. However, we continue to be intrigued by the complexity of her case, particularly with respect to her motivation to create environments that conceal her memory disability while she seems less concerned about her physical disability (i.e., her gait is slow and unsteady, her right hand is clasped due to hemiparesis), the accommodations for which (e.g., use of handicap parking) she strategically uses to conceal the cognitive disability. Although the extent and degree to which many of these variables (preserved intellect, education, insight, site of lesion, sex, physical disability) contribute to functional outcome awaits further study, we echo the call by Tate and O'Conner et al. that greater attention to characterizing and documenting the social and emotional lives of amnesic patients will enrich both our clinical and theoretical understanding of amnesia.

The case presented here also has implications for clinical practice and theoretical perspectives of rehabilitation. We hope the detailed presentation of the strategies and compensatory techniques Angie employs to cope with her memory impairment will have immediate application for clinical practice and that this case raises the bar for what we thought possible with respect to functional outcome following amnesia. That is not to say, of course, that all patients with amnesia should expect the same positive outcome. Angie was young and highly educated at the onset of her amnesia, has modest medial temporal lobe damage, has superior intellectual abilities, intact executive functions, is insightful, is extremely motivated and has responded quite well to the social and emotional consequences of her amnesia. Yet, in presenting this case to a number of clinicians, we were reminded that based on her neuropsychological profile and a long history of poor functional outcome in the literature, recommendations for 24 hour supervision and against driving and employment would be routine in a case such as this. Indeed, exactly such recommendations were made to Angie and

her family. While it should be noted that Angie came to our attention long after her head injury (after her engagement ended and her failed attempt to return to her teaching job) and what we imagine were likely difficult months and years of refining the real-world abilities described here, we are hopeful that this case will encourage clinicians to conceive of a different possibility for patients with profound memory impairments, and support the often arduous and volatile road associated with long-term rehabilitation and community re-entry.

In terms of theoretical perspectives of rehabilitation, we believe Angie's case provides an excellent illustration of the theory driven rehabilitation framework offered by Ylvisaker and Feeney (1998). This treatment approach is built on Vygotsky's (1978) work on social interaction and cognitive development and the tenet that high order cognitive functions derive from the internalization of one's socio-cultural interactions with people and the environment, and that with time and experience, as one becomes more proficient and independent, these external practices are internalized. To function in her environment, Angie has externalized her records and representations of people and the environment (e.g., notes on kitchen cabinets; color coded flow charts at work; notes of phone conversations) that give her a sense of the larger record of her experience over time and in the absence of internal knowledge for such information. With practice, some of these routines gradually become internalized again and external cues are less necessary (i.e., Angie no longer requires sticky notes on kitchen cabinets). For knowledge that does not become internalized (e.g., what tasks at work require her attention), a well-developed and visible routine supports independent functioning (i.e., flow charts at work). Although Angie's accomplishments were achieved without the benefit of formal rehabilitation, we see the interaction of internal and external knowledge and the distributed nature of her memory in her environment (cf., Hutchins, 1995; Manier, 2004).

Since the onset of her amnesia, Angie has taken on a number of novel social and interpersonal roles (i.e., wife, mother) which have shaped and contributed to what we believe is an evolving identity and sense of self. In social psychology and cognitive neuroscience, there is great interest in and debate over the role of memory, and other cognitive systems, in the construction of self (e.g., Conway, 2005; Damasio, 1999; Ochsner et al., 2005; Kihlstrom, Beer, & Klein, 2002; Klein, Loftus, Kihlstrom, 1996; Klein, Rozendal, & Cosmides, 2002; Levine et al., 1998). Much of this work has been directed at understanding the role of episodic memory in the formation and maintenance of identity and self. The case of Angie suggests to us that knowledge about the self can evolve and be updated and behavior modified in the absence of intact episodic memory. Other studies and anecdotal examples concur. Claparede (1911/1951) reported a woman with amnesia who could not remember that he had pricked her hand with a hidden pin while shaking her hand, and later refused to shake hands with him again. It was shown in the patient Boswell that despite his inability to explicitly learn to recognize the hospital staff, he consistently favored those with whom he had repeated pleasant interactions over those with whom he had negative encounters (Tranel, Damasio, & Damasio, 1993). It has also been shown that amnesic patients exhibit as much behavior-induced attitude change as control participants (Lieberman, Ochsner, Gilbert, & Schacter, 2001) and that amnesic patients can acquire short-hand in their discourse, or "common ground," as a result of repeated communicative histories with a familiar partner (Duff et al., 2006) both of which occur in the absence of episodic memory. While answers to the question of what we know about ourselves in the absence of being able to explicitly remember our personal experiences remain unanswered, we believe that the detailed study of the social and emotional lives of patients with amnesia as well as the breadth and scope of unconscious memory and learning processes in amnesia, will contribute to neuropsychological and cognitive neuroscience understandings of self and identity.

Finally, Angie looks to and plans for the future. While preparing this manuscript, she has transitioned to a new phase of her life. Although Angie made realistic career choices that

allowed her full-time employment in her field, the physical and emotional effort to be successful in the context of such a dense amnesia have had a cost. Angie reports she has little energy and time left for her husband, friends, and other activities. Wanting to spend more time with family and friends, traveling, and working with children, and having proven to herself that she could manage being employed, she has quit her job and has since become more involved with the family farm, traveling (most recently to Hawaii), and currently volunteers two days a week at an elementary school working with children in a remedial reading program. We see this as yet another example of her keen insight into her situation and of making decisions that are consistent with her abilities and her desire to have a meaningful and rewarding life. Angie's case stands in stark contrast to other cases of profound anterograde amnesia previously reported.

Acknowledgments

This research was supported by NIDCD grant 1F32DC008825, Program Project Grant NINDS NS 19632, and NIMH grant RO1 MH062500.

References

- Alexander M, Freedman M. Amnesia after anterior communicating artery rupture. *Neurology* 1984;34:752–759. [PubMed: 6539437]
- Auerbach SH. Neuroanatomical correlates of attention and memory disorders in traumatic brain injury: An application of neurobehavioral subtypes. *Journal of Head Trauma Rehabilitation* 1986;1:1–12.
- Beck, A. Beck Depression Inventory. 2. San Antonio: The Psychological Corporation; 1996.
- Benton, A.; Hamsher, K.; Sivan, A. Multilingual Aphasia Examination. 3. Florida: Psychological Assessment Resources, Inc; 1994.
- Benton, A.; Sivan, A.; Hamsher, K.; Varney, N.; Spreen, O. Benton Laboratory of Test. Florida: Psychological Assessment Resources, Inc; 1994.
- Butters, N.; Cermak, L. *Alcoholic Korsakoff's Syndrome: An Information Processing Approach*. New York: Academic Press; 1986.
- Cermak L, O'Conner M. The anterograde and retrograde retrieval ability of a patient with amnesia due to encephalitis. *Neuropsychologia* 1983;21:213–234. [PubMed: 6877576]
- Claparede, E. Recognition and 'me'ness. In: Rapaport, D., editor. *Organization and pathology of thought*. New York: Columbia University Press; 1951. (Reprinted from *Archives de Psychologies* 1911;11:79–90)
- Cohen, NJ. Preserved learning capacity in amnesia: Evidence for multiple memory systems. In: Butters, N.; Squire, L., editors. *The neuropsychology of memory*. New York: Guilford Press; 1984. p. 83–103.
- Cohen, NJ.; Banich, MT. *Neuropsychology: The neural bases of mental function*. 2. Boston: Houghton-Mifflin; 2003. Memory. In M.T. Banich.
- Cohen, NJ.; Eichenbaum, H. *Memory, amnesia, and the hippocampal system*. Cambridge, MA: MIT Press; 1993.
- Cohen NJ, Squire L. Preserved learning and retention of a pattern analyzing skill in amnesia: Dissociation of know how and know that. *Science* 1980;210:207–210. [PubMed: 7414331]
- Conway M. Memory and the self. *Journal of Memory and Language* 2005;53:594–628.
- Corkin S. Lasting consequences of bilateral medial temporal lobectomy: clinical course and experimental findings in H.M. *Semin Neurol* 1984;4:252–262.
- Damasio, AR. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. Harcourt Brace; New York: 1999.
- Damasio A, Eslinger P, Damasio H, Van Hoesen G, Cornell S. Multi-modal amnesic syndrome following bilateral temporal and frontal damage: the case of D.R.B. *Archives of Neurology* 1985;42:252–259. [PubMed: 3977656]
- Damasio A, Graff-Radford N, Eslinger P, Damasio H, Kassell N. Amnesia following basal forebrain lesions. *Archives of Neurology* 1985;42:263–271. [PubMed: 3977657]

- Damasio, A.; Tranel, D.; Damasio, H. Amnesia caused by herpes simplex encephalitis, infarctions in basal forebrain, Alzheimer's disease and anoxia/ischemia. In: Boller, F.; Grafman, J., editors. *Handbook of Neuropsychology*. Vol. 3. Amsterdam: Elsevier; 1989.
- De Renzi E, Zambolin A, Crisi G. The pattern of neuropsychological impairment associated with left posterior cerebral artery infarcts. *Brain* 1987;110:1099–1116. [PubMed: 3676694]
- D'Esposito M, Verfaellie M, Alexander M, Katz D. Amnesia following traumatic bilateral fornix transection. *Neurology* 1995;45:1546–1550.
- Diener E, Emmons R, Larsen J, Griffin S. The satisfaction with life scale. *J Personality Assessment* 1985;49(1):71–75.
- Duff MC, Hengst J, Tranel D, Cohen NJ. Development of shared information in communication despite hippocampal amnesia. *Nature Neuroscience* 2006;9 (1):140–146.
- Eichenbaum, H.; Cohen, NJ. *From conditioning to conscious recollection: Memory systems of the brain*. Oxford University Press: New York; 2001.
- Elliott M. Coping with a memory loss – a personal perspective. *Cognitive Rehabilitation* 1990;8:8–10.
- Gabrieli JDE. Cognitive neuroscience of human memory. *Annual Review of Psychology* 1998;49:87–115.
- Golden, C. *Stroop Color and Word Test*. Illinois: Stoelting; 1978.
- Grant, D.; Berg, E. *Wisconsin Card Sorting Test*. Florida: Psychological Assessment Resources, Inc; 1993.
- Hutchins, E. *Cognition in the Wild*. Cambridge, MA: MIT Press; 1995.
- Jones RD, Grabowski T, Tranel D. The neural basis of retrograde memory: Evidence from positron emission tomography for the role of non-mesial temporal lobe structures. *Neurocase* 1998;4:471–479.
- Kaplan, E.; Goodglass, H.; Weintraub, S. *The Boston Naming Test*. Philadelphia: Lea and Febiger; 1983.
- Kihlstrom, J.; Beer, J.; Klein, S. Self and identity as memory. In: Leary, MR.; Tangney, J., editors. *Handbook of self and identity*. New York: Guilford Press; 2002. p. 68-90.
- Klein S, Loftus J, Kihlstrom J. Self-knowledge of an amnesic patient: Toward a neuropsychology of personality and social psychology. *Journal of Experiential Psychology: General* 1996;125(3):250–260.
- Klein S, Rozendal K, Cosmides L. A social-cognitive neuroscience analysis of the self. *Social Cognition* 2002;20(2):105–135.
- Levine B, Black S, Cabeza R, Sinden M, McIntosh A, Toth J, Tulving E, Stuss D. Episodic memory and the self in a case of isolated retrograde amnesia. *Brain* 1998;121:1951–1973. [PubMed: 9798749]
- Lieberman M, Ochsner K, Gilbert D, Schacter D. Do amnesics exhibit cognitive dissonance reduction? The role of explicit memory and attention in attitude change. *Psychological Science* 2001;12(2):135–140. [PubMed: 11340922]
- Manier D. Is memory in the brain: Remembering as social behavior. *Mind, Culture, and Activity* 2004;11 (4):251–266.
- Morris M, Bowers D, Chatterjee A, Heilman K. Amnesia following discrete basal forebrain lesion. *Brain* 1992;115(6):1827–1847. [PubMed: 1486463]
- O'Conner M, Butters N, Miliotis P, et al. The dissociation of anterograde and retrograde amnesia in a patient with herpes encephalitis. *Journal of Clinical and Experimental Neuropsychology* 1992;14:159–178. [PubMed: 1572943]
- O'Conner, M.; Cermak, L.; Seidman, L. Social and emotional characteristics of a profoundly amnesic postencephalitic patient. In: Campbell, R.; Conway, M., editors. *Broken memories: Case studies in memory impairment*. Oxford: Blackwell Publishers Ltd; 1995. p. 45-53.
- Ochsner K, Beer J, Robertson E, Cooper J, Gabrieli J, Kihlstrom J, D'Esposito M. The neural correlates of direct and reflected self-knowledge. *NeuroImage* 2005;797–814. [PubMed: 16290016]
- Parkin, AJ.; Leng, NRC. *Neuropsychology of the amnesic syndrome*. Hove, UK: Erlbaum; 1993.
- Reitan, R.; Wolfson, D. *The Halstead-Reitan Neuropsychological Test Battery*. Tucson, AZ: Neuropsychology Press; 1985.

- Rempel-Clower N, Zola SM, Squire L, Amaral D. Three cases of enduring memory impairment after bilateral damage limited to the hippocampal formation. *Journal of Neuroscience* 1996;16:5233–5255. [PubMed: 8756452]
- Ryan JD, Cohen NJ. Processing and short-term retention of relational information in amnesia. *Neuropsychologia* 2004;42:497–511. [PubMed: 14728922]
- Ryan JD, Althoff RR, Whitlow S, Cohen NJ. Amnesia is a deficit in relational memory. *Psychological Science* 2000;11(6):454–461. [PubMed: 11202489]
- Schmolck H, Kensinger E, Corkin S, Squire L. Semantic knowledge in patient H.M. and other patients with bilateral medial and lateral temporal lobe lesions. *Hippocampus* 2002;12:520–533. [PubMed: 12201637]
- Sokol, K.; Heinemann, A.; Bode, R.; Shin, J.; Van de Venter, L. Community participation after TBI: Factors predicting return to work and life satisfaction. Poster presented at the 127th Annual Meeting of the American Public Health Association; Chicago, IL. 1999.
- Squire LR. Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review* 1992;99:195–231. [PubMed: 1594723]
- Stern Y. What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society* 2002;8:448–460. [PubMed: 11939702]
- Tate, R. Emotional and social consequences of memory disorders. In: Baddeley, AD.; Kopelman, MD.; Wilson, BA., editors. *The handbook of memory disorders*. 2. West Sussex, England: John Wiley & Sons Ltd; 2002. p. 785–808.
- Tranel D, Enekechi N, Manzel K. A test for measuring recognition and naming of landmarks. *J Clin Exp Neuropsychol* 2005;27:102–26. [PubMed: 15814445]
- Tranel, D.; Damasio, H.; Damasio, AR. Amnesia caused by herpes simplex encephalitis, infarctions in basal forebrain, and anoxia/ischemia. In: Boller, F.; Grafman, J., editors. *Handbook of neuropsychology*. 2. Amsterdam: Elsevier Science; 2000. p. 85–110.
- Tranel D, Jones RD. Knowing what and knowing when. *Journal of Clinical and Experimental Neuropsychology* 2006;28:43–66. [PubMed: 16448975]
- Ver der Werf Y, Witter M, Uylings H, Jolles J. Neuropsychology of infarctions in the thalamus: a review. *Neuropsychologia* 2000;38:613–627. [PubMed: 10689038]
- Vygotsky, LS. *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press; 1978.
- Wechsler, D. Wechsler Adult Intelligence Scale. 3. New York: Psychological Corporation; 1997a.
- Wechsler, D. Wechsler Memory Scale. 3. New York: Psychological Corporation; 1997b.
- Wilson, BA. *Case Studies in Neuropsychological Rehabilitation*. New York: Oxford University Press; 1999.
- Wilson, BA. Memory problems in brain-injured adults. In: Baddeley, AD.; Kopelman, MD.; Wilson, BA., editors. *The handbook of memory disorders*. 2. West Sussex, England: John Wiley & Sons Ltd; 2002. p. 655–682.
- Wilson, BA.; Alderman, N.; Burgess, P.; Emslie, H.; Evans, J. *Behavioral Assessment of the Dysexecutive Syndrome*. United Kingdom: Thames Valley Test Company; 1996.
- Wilson BA, Baddeley A, Kapur N. Dense amnesia in a professional musician following herpes simplex virus encephalitis. *Journal of Clinical and Experimental Neuropsychology* 1995;17(5):668–681. [PubMed: 8557808]
- Wilson BA, Watson PC. A practical framework for understanding compensatory behavior in people with organic memory impairment. *Memory* 1996;4:465–486. [PubMed: 8884742]
- Wilson, BA.; Wearing, D. Prisoner of consciousness: A state of just awakening following herpes simplex encephalitis. In: Campbell, R.; Conway, MA., editors. *Broken memories: Case studies in memory impairment*. Cambridge, MA: Blackwell Publishers, Inc; 1995. p. 14–30.
- Ylvisaker, M.; Feeney, T. *Collaborative brain injury intervention: Positive everyday routines*. San Diego, CA: Singular Publishing Group, Inc; 1998.
- Zola-Morgan S, Squire L, Amaral D. Human amnesia and the medial temporal region: enduring memory impairment following a bilateral lesion limited to field CA1 of the hippocampus. *Journal of Neuroscience* 1986;6:2950–2967. [PubMed: 3760943]

Table 1

Intellectual abilities as measured by the Wechsler Adult Intelligence Scale-III

	Age-Corrected SS	Percentile	Interpretation
Verbal Subtests			
Vocabulary	15	95	Superior
Similarities	15	95	Superior
Information	13	84	High Average
Arithmetic	12	75	High Average
Digit Span	5	5	Borderline
L-N Sequencing	3	1	Extremely Low
Comprehension	18	99	Very Superior
Performance Subtests			
Picture Completion	15	95	Superior
Symbol Substitution	9	37	Average
Block Design	12	75	High Average
Matrix Reasoning	17	99	Very Superior
Picture Arrangement	18	99	Very Superior
Symbol Search	11	63	Average
Object Assembly	11	63	Average
Index Scores			
Verbal Comprehension	124	95	Superior
Perceptual Organization	130	98	Very Superior
Working Memory	80	9	Low Average
Processing Speed	99	47	Average
IQ Scores			
Verbal	118	88	High Average
Performance IQ	130	98	Very Superior
Full Scale IQ	126	96	Superior

Table 2

Performance on the Standardized Measures of Memory

Wechsler Memory Scale –III			
Subtest	Age-Corrected SS	Percentile	Interpretation
Logical Memory I	7	16	Low Average
Faces I	6	9	Low Average
Verbal Paired Associates I	3	1	Extremely Low
Family Pictures I	4	2	Borderline
Letter-Numbering Sequencing	4	2	Borderline
Spatial Span	2	<1	Extremely Low
Logical Memory II	3	1	Extremely Low
Faces II Recognition	4	2	Borderline
Verbal Paired Associates II	4	2	Borderline
Family Pictures II	2	<1	Extremely Low
Index Scores			
Auditory Immediate Index	71	3	Borderline
Visual Immediate Index	65	1	Extremely Low
Immediate Memory Index	61	<1	Extremely Low
Auditory Delayed Index	61	<1	Extremely Low
Visual Delayed Index	56	<1	Extremely Low
Auditory Recognition Delayed Index	55	<1	Extremely Low
General Memory Index	49	<1	Extremely Low
Working Memory	63	1	Extremely Low
Rey Complex Figure Test			
Copy	36/36		Normal
30 minute recall	0/36		Severely Impaired
Rey Auditory Verbal Learning Test			
Trial 5	3/15		Severely Impaired
30 minute recall	0/15		Severely Impaired

Table 3

Performance on the Iowa Autobiographical Memory Questionnaire

Time Period	Percent Correct
Early Childhood and Adolescence	97%
Young Adulthood	80%
Middle Adulthood	N/A
Late Adulthood	N/A
Recent Life (past year)	44%

Table 4

Performances on Tests of Executive Functions

Test	Score	Percentile	Interpretation
Wisconsin Card Sorting Test	^a Categories = 6	>16	Normal
	^a Perseverative Errors = 5	39	Normal
Controlled Oral Word Association	^a F (60") = 14	47	Normal
	^a A (60") = 20	97	Superior
	^a S (60") = 17	66	Normal
Stroop	^b Color-Word = 50	50	Normal
Trailmaking Test	^b Trails A = 7	34	Normal
	^b Trails B = 12	52	Normal
Behavioral Assessment of Dysexecutive Syndrome	^c 108	70	Average

NOTE:

^a raw score;^b T score;^c standard score