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Names and Words Without Meaning: Incidental Postmorbid Semantic Learning in a Person With Extensive Bilateral Medial Temporal Damage

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The authors describe a densely amnesic man who has acquired explicit semantic knowledge of famous names and vocabulary words that entered popular culture after the onset of his amnesia. This new semantic knowledge was temporally graded and existed over and above the implicit memory he demonstrated in reading speed and accuracy, familiarity ratings, and his ability to make correct guesses on unfamiliar items. However, his postmorbid knowledge was limited to verbal labels denoting famous people and words; he possessed virtually no explicit knowledge of the meaning of these words or the identities of these individuals, although there was some evidence that some of this information had been acquired at an implicit level. Findings are discussed in the context of a neural network model (J. L. McClelland, B. L. McNaughton, & R. C. O'Reilly, 1995) of semantic acquisition.

The phenomenon of preserved postmorbid semantic learning in amnesia lies at the heart of current theoretical debates regarding the psychological and neuroanatomical distinction between episodic and semantic memory. One view holds that episodic and semantic memory are mediated by separate neural mechanisms and can exist independently of one another; amnesia is considered to be a selective impairment of episodic memory, and patients are predicted to retain the ability for new semantic acquisition (e.g., Tulving, Hayman, & MacDonald, 1991; Vargha-Khadem et al., 1997). In contrast, a second view (consolidation theory) suggests that episodic and semantic memory depend on the same neural mechanisms in the medial temporal lobe and predicts that virtually no new semantic learning will occur in the absence of a functioning episodic system (Squire, 1986, 1987; Squire, Knowlton, & Musen, 1993). Thus, quantitative and qualitative investigations of amnesic individuals' anterograde memory for semantic information will not only help to resolve this debate but also will have important implications for theories of knowledge acquisition in people with neurologically intact brains.

Experimental and observational data regarding postmorbid semantic acquisition in amnesia have been inconsistent; some studies have found evidence of explicit semantic learning in amnesic patients (e.g., Kitchener, Hodges, & McCarthy, 1998; Schacter, Harbluk, & McLachlan, 1984; Shimamura & Squire, 1987; Tulving et al., 1991; Vargha-Khadem et al., 1997), whereas others have failed to find such evidence (Gabrieli, Cohen, & Corkin, 1983, 1988; Rozin, 1976; Verfaellie, Croce, & Milberg, 1995). These inconsistencies reflect the enormous amount of between-study variability that exists with respect to individual patient factors (e.g., age at onset, extent and location of lesion) and experimental factors (e.g., task difficulty and demands, stimulus attributes, characteristics of the learning environment, amount of training and exposure). One consistent finding that has emerged from the literature, however, is that amnesic patients who do show some preserved semantic learning ability tend to perform better on tests of recognition and familiarity as compared with tests of recall (e.g., Aggleton & Brown, 1999; Kitchener et al., 1998; Verfaellie, Koseff, & Alexander, 2000). These observations have been taken to suggest that the new information acquired by amnesic patients may be impoverished, nonelaborated, and inflexible; information acquired in the absence of the hippocampus may not become integrated into preexisting knowledge structures, making it difficult to access in explicit recall (Dopkins, Kovner, & Goldmeier, 1990; Eichenbaum, Otto, & Cohen, 1994; Kitchner et al., 1998; Schacter, 1985, 1987; Shimamura & Squire, 1987; Verfaellie et al., 1995, 2000).

These findings, however, do not necessarily imply that the fundamental deficit underlying anterograde amnesia is one of access or retrieval or that the recognition–recall dimension is most informative in describing the preserved and impaired learning abilities of amnesic patients. One

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problem with drawing such conclusions is that recognition and recall tasks typically have involved different types of information (Gabrieli et al., 1983, 1988; Kitchener et al., 1998; Shimamura & Squire, 1987; Verfaellie et al., 2000). Recognition may rely on familiarity judgments of famous names and faces. These tasks can be performed using perceptual memory exclusively and do not necessarily require that the subject access any semantic meaning associated with the stimulus. In contrast, recall typically taps knowledge that is more detailed and elaborate, such as definitions of vocabulary terms and biographical information about famous people. These tasks require the subject to access the semantic representations of stimuli. Poor performance may reflect a selective deficit in recall, but it may also reflect an inability to acquire detailed elaborate semantic representations of new information. Nonrecall paradigms were used in one study to assess semantic acquisition of vocabulary definitions and public event knowledge (e.g., Kitchener et al., 1998; see also Warrington & McCarthy, 1988). Use of such paradigms has been rare; however, they have not been used in the assessment of new knowledge about famous people.

A second problem with relying on the recognition–recall dimension to describe the semantic acquisition abilities of amnesic individuals is that the forced-choice recognition paradigms typically used in these studies do not allow the experimenter to determine the extent to which correct responses reflect true explicit memory representations that become activated immediately and reliably on encountering the stimulus, as opposed to implicit or partial representations that guide guessing behavior. Furthermore, some patients with large medial temporal lesions extending outside the hippocampus proper to include peri-hippocampal regions do very poorly on recognition tests, showing virtually no advantage over explicit recall; other patients show mixed performance on tests of recognition, depending on the type of information being examined (Aggleton & Brown, 1999; Verfaellie et al., 2000; Warrington, 1996).

Thus, a comprehensive understanding of postmorbid learning in amnesia requires investigation, not only of the types of tasks (recognition or recall) that are best performed but also of how performance on the same type of task can vary with other stimulus factors, such as information content (names, words, faces, events), type of association required to learn the information (relational or arbitrary; see Eichenbaum et al., 1994, for an explanation), and degree to which the information is elaborated. In addition, assessing the confidence with which recognition responses are given for new postmorbid concepts and entities will provide unique information about the types of knowledge and semantic associations that can be acquired in amnesia and the extent to which this knowledge is elaborated and integrated into existing semantic networks.

In an attempt to explore further how amnesic patients' semantic acquisition abilities vary with task demands and stimulus attributes, we examined incidental learning of famous names and vocabulary terms in K.C., a person with extensive bilateral hippocampal damage. We address issues concerning the degree to which new knowledge is elaborated, flexible, and consciously accessible by using recognition paradigms to assess familiarity with and semantic knowledge of recent vocabulary words and famous people, by examining explicit recognition separately from correct guesses and by using speeded reading and pronunciation tasks as measures of implicit semantic memory.

Method

Participants

K.C. is a 47-year-old right-handed man with 15 years of formal education. He has been tested extensively over the 20 years since he suffered a severe closed head injury and became densely amnesic in October of 1981. Magnetic resonance and computerized tomography scans illustrating the specific loci of brain damage suffered by K.C. have been documented elsewhere (e.g., Tulving, 1989; Tulving et al., 1991; Tulving, Schacter, McLachlan, & Moscovitch, 1988). K.C. suffered almost complete bilateral destruction of the hippocampus in addition to a right occipital lesion and a left fronto-parietal lesion. Although some of K.C.'s peri-hippocampal tissue remains intact, it is severely atrophied and its functionality is questionable. It is unlikely that the preserved tissue is effectual; however, it is not possible to determine with certainty the full extent of K.C.'s peri-hippocampal damage. He has no obvious lesion to the temporal neocortex or insular cortex in either hemisphere. His case history and neuropsychological profile are described in detail in recent articles exploring his autobiographical memory (Westmacott, Leach, Freedman, & Moscovitch, 2001) and his remote semantic memory (Rosenbaum et al., 2000). In a 1996 neuropsychological assessment, K.C. received a full scale IQ score of 88 and scores of 96 and 79 on the Verbal and Performance scales, respectively. He scored poorly on the Wechsler Memory Scale—Revised (Wechsler, 1987): His General Memory score is 61, his Verbal score is 67, and his Visual score is 69. K.C. performed at chance level on the Warrington Recognition Test (Warrington, 1984) for both faces and words, but his naming abilities and vocabulary remain well within the range of normal. In an assessment using tasks identical to those of the present study, Westmacott and Moscovitch (in press) found K.C.'s premorbid semantic memory for famous names and words to be intact across all tasks, except for knowledge acquired in the 5-year time period predating his injury.

K.C.'s performance was contrasted with that of 6 male control participants, matched with K.C. in terms of age (M = 46.2 years), ethnic background (White Anglo-Saxon), education (M = 19 years), and handedness (right). None of the control participants had any sign of neurological, medical, or psychological impairment. Data were collected during several separate testing sessions between the spring of 1999 and January of 2000.

Materials

We assessed knowledge of famous names for the time period between 1980 and the present. The stimulus set consisted of 160 names of famous people gathered from a wide range of twentieth century historical literature sources (Aaker, 1997; Commire, 1994; Gann, 1997; Ziegler, 1990). The names were grouped according to the 5-year time period within which they first became famous. We attempted to restrict the stimulus set to individuals whose fame was of limited duration such that it did not extend far beyond one particular time period; however, this task proved to be extremely difficult, resulting in the inclusion of some suboptimal stimuli. Each of the four 5-year time periods from 1980 through to the

present day contained a total of 40 famous names, 10 names associated with each of four categories: arts (i.e., actors, musicians, authors, e.g., Celine Dion, Michael J. Fox), athletics (e.g., Shaquille O'Neil, Tiger Woods), politics (e.g., Mel Lastman, Mike Harris), and miscellaneous (e.g., Paul Bernardo, Monica Lewinsky). We used an individual's nickname in lieu of his or her real name if we judged that the majority of media and public references to that individual involved use of the nickname (e.g., Magic Johnson). In addition, we constructed a large set of distractor items using nonfamous names representing the same range of nationalities as the experimental stimuli.

We assessed lexical knowledge from 1980 to the present using a series of experimental tests that tapped knowledge of new words and terms that have recently entered the English vocabulary. The stimulus set consisted of 180 English vocabulary terms gathered from a wide range of encyclopedic sources (Algeo, 1991; Ayto & Simpson, 1992; Barnhart, 1994; Cherry Lane Music Company, 1995; Gozzi, 1990; Soukhanov, 1995; Young, 1993). We grouped the words according to the 5-year time period within which they were judged to have officially entered the English language. Each 5-year time period from 1980 through to the present day contained a total of 30 English terms; these terms contained single or multiple words and came from either slang or formal English vocabularies. We chose the words included in this set such that they were appropriate for participants with a North American (specifically Canadian) background. In addition, we constructed a large set of distractor items using pseudowords (i.e., pronounceable nonwords) to ensure that participants could not rely on their knowledge of English phonology to perform the tasks.

Experimental Tasks

Reading times for famous names versus scrambled names. We selected 15 famous names from each of the four 5-year time periods for inclusion in the reading times task. Each of the four categories (arts, athletics, politics, and miscellaneous) was represented in the set of famous names chosen for each time period. We constructed a comparison set of 15 nonfamous names for each time period by scrambling the first and last names within each subset of famous names. Thus, the sets of famous and nonfamous names for each time period contained the exact same set of first and last names; however, these names were arranged into pairs differently for the two sets. This design permitted direct comparisons between the time taken to read famous names as opposed to nonfamous names. Furthermore, because last names alone often carry the designation of "famous" (e.g., Cruise, Clinton), finding a difference between famous and scrambled names would suggest that the effect of fame on reading time is very robust and that this effect may provide a sensitive valid measure of semantic memory.

The subsets of famous and nonfamous (scrambled) names were presented in typed columns on separate sheets of paper. In addition, we constructed three practice lists, each consisting of 15 nonfamous names, from the set of distractors; there was no overlap between the practice items and the experimental items. We asked participants to read aloud each list of names as quickly and as accurately as possible. Reading times, in hundredths of seconds, were recorded for each list using a stopwatch. Participants' reading accuracy and the ease with which each list was read were noted also.

Recognition of famous names in a three-alternative forced-choice task. We used the same set of famous names utilized in the reading times task for the name recognition task. Each famous name was paired with two nonfamous names matched with respect to gender and ethnicity. These nonfamous distractor names were not scrambled pairs of famous names, thereby rendering the task more sensitive in its ability to detect existing semantic representations of the famous individuals. We presented these name triplets to participants one at a time and in random order. We told participants that only one of the three presented names belonged to a famous individual and asked them to identify which one it was by pointing to the appropriate name. Participants were required to provide a response on every trial and were asked to indicate whether their responses were guided by the retrieval of specific memory representations or whether they were simply guessing. We recorded guessing responses separately from true memory responses to permit a comparison between performance on explicit tasks and tasks that tapped both conscious and unconscious processing (Reingold & Toth, 1996). Accuracy was recorded for each trial, but participants did not receive any feedback regarding their performance.

Familiarity ratings of famous and nonfamous names. We used the same set of famous names utilized in the first two tasks again in the familiarity ratings task. We also included 60 of the nonfamous names used as distractor items in the famous name recognition task. These 120 names were arranged in random order and were presented to participants as a typed list. We asked participants to read each name and to indicate its degree of subjective familiarity by circling the appropriate number on a 7-point rating scale (1 = *completely unfamiliar* and 7 = *extremely familiar*).

Classification of famous names into the correct category. We used the same set of 60 famous names, each matched with three category descriptors (e.g., Canadian politician, Hollywood actor, poet), such that only one descriptor provided an accurate description of the famous individual. Famous names, along with their respective category descriptors, were presented to participants in random order, one at a time. We asked participants to point to the category descriptor that best fit the famous individual. This task permitted a more detailed and elaborate evaluation of semantic knowledge about famous individuals than is possible with simple name recognition.

Matching of famous last names with the correct first names. We selected 15 famous names from each time period, representing each of the four descriptive categories, from the original stimulus set for inclusion in the matching task. This set of famous names was completely nonoverlapping with respect to the set used in the four previous tasks to ensure that the task was tapping long-term semantic memory and not simply recognition of previously presented experimental items. These famous first name–last name pairs subsequently were matched with two alternate first names; thus, pairing the famous last name with either of these alternate first names resulted in a first–last name pair that no longer belonged to a famous individual. We chose alternate first names in such a way as to match the correct first name with respect to gender and nationality or ethnicity. On each trial, we presented participants with a famous last name (e.g., Clinton) and asked them to choose the correct first name from a set of three possibilities (e.g., Bill, David, John).

Matching movies or television programs with the correct actor. We selected 120 titles of motion pictures or television programs for inclusion in the matching task (10 movie or television show titles dating from each of the four 5-year time periods). Each title was matched with three famous names: one name belonged to a famous actor who starred in that show or movie, one name belonged to another famous actor from the given time period who did not star in the target movie or television show (i.e., incorrect condition), and the third name belonged to a famous individual from the given time period who is (was) not an actor (i.e., unrelated condition). Moreover, within each set of names, the three famous individuals were matched with respect to gender. Movie

and television show titles were presented individually and in random order. We asked participants to select, from a choice of three alternatives, the name of the actor starring in the movie or television program.

Reading times for real words versus scrambled words. We selected 15 English vocabulary terms from each of the four 5-year time periods from the original stimulus set for inclusion in the reading times task. A comparison set of 15 pseudowords was constructed for each time period by scrambling the syllables within each subset of vocabulary terms. Thus, the sets of real words and pseudowords for each time period contained the exact same set of speech sounds; however, these syllables were arranged differentially into word units for the two sets. This design permitted direct comparisons to be made between the time taken to read real words as opposed to pseudowords. Three practice lists, each consisting of 15 pseudowords, were constructed such that there was no overlap with any of the experimental items. The procedure was identical to that in the name reading task.

Recognition of English words in a three-alternative forced-choice task. We used the same set of 60 English vocabulary terms used in the reading times task in the word recognition task; each vocabulary term then was paired with two pseudowords. We presented these groups of three to participants one at a time and in random order. We told participants that only one of the three terms was an actual English word and asked them to identify it by pointing manually. Accuracy was recorded for each trial, but participants did not receive any feedback regarding their performance. The rest of the procedure was identical to that in the famous names recognition task.

Providing definitions or descriptions of English vocabulary terms. For each of the English vocabulary terms identified correctly in the forced-choice recognition task, we asked the participant to provide a brief description or definition. Definitions were scored as correct or incorrect; no discriminations were made regarding the quality of the responses, as the goal of the task was to determine whether or not the participant had some knowledge of each word's meaning. Accuracy data were recorded, and no feedback was provided. This task did not use a forced-choice paradigm, and null responses were accepted.

Choosing the correct vocabulary definition. We asked K.C. to match each of the vocabulary words from the recognition task (whether identified correctly or not) with the correct definition in a four-alternative forced-choice task. Control participants did not perform this task because of their near perfect performance in the explicit definition task. The rest of the procedure was identical to that in the recognition task.

Results

A summary of K.C.'s and control participants' performance in each task, averaged across the four time periods, is presented in Table 1. Performance scores and percentages are presented by time period for the famous names tasks in Table 2 and for the vocabulary tasks in Table 3. Because of the high levels of explicit memory performance among control participants, there was very little change in performance patterns when guessing responses were considered; therefore, only levels of explicit memory performance are presented for the control groups. We calculated a second performance score—explicit recognition plus correct guesses—for K.C. only. The validity of these two performance scores as measures of explicit and implicit (or indirect) memory was suggested by the fact that K.C. made no errors on any of the trials that he indicated were true memory responses; all errors were made on items for which he was unsure and asked to guess. Although this does not necessarily mean that his guessing score is a pure measure of implicit memory (it is more likely to be a measure of indirect memory or familiarity that is partly explicit and partly implicit), it does imply that his explicit scores reflect the amount of knowledge that is consciously accessible to him. Because K.C. did not make any incorrect explicit responses, the number of incorrect guesses is equal to the total number of items in the time period minus the second performance score (explicit + guess). Finally, the consistently high performance of the control participants across time periods and tasks suggests that the famous names selected for inclusion in the stimulus set are generally familiar to men of K.C.'s age cohort.

K.C.'s Postmorbid Knowledge of Famous Names

K.C. read famous names faster than scrambled names in all four time periods, although this difference in reading speed was not as pronounced as it was in controls. Furthermore, K.C. demonstrated a difference in reading times for recently famous names versus scrambled names that was less pronounced than that which he demonstrated for remote

Table 1
Performance on Tests of Postmorbidly Acquired Knowledge of Famous Names and Vocabulary Terms, Expressed in Percentage Correct and Averaged Across Time Periods

Test	K.C.		Controls	
	Explicit	Explicit + guess	*M*	*SD*
Famous names				
Recognition (%)	83.3	88.0	98.9	4.7
Familiarity rating (max. = 7)	4.6		6.7	1.1
Categorization (%)	5.0	55.0	98.9	4.9
Television and movie: Actor matching (%)	25.0	75.0	97.3	7.3
First–last name matching (%)	55.0	77.0	98.7	5.1
Vocabulary terms				
Recognition (%)	82.0	91.7	99.1	2.6
Recall definition (%)	25.0		94.3	3.9
Recognize definition (%)	43.3	73.3		

Note. max. = maximum.

Table 2
K.C.'s and Controls' Performance on the Famous Names Tasks: Means and Standard Deviations by Time Period

Task and group	1980	1985	1990	1995	Fillers
Name reading (s)[a]					
K.C.	3.36[b]	3.87[b]	3.09[b]	3.42[b]	
Control					
M	6.86	6.58	6.80	6.76	
SD	0.54	0.60	0.54	0.31	
Name reading (errors out of 15)					
K.C.					
15 item	2[b] (13.3%)	2[b] (13.3%)	4[b] (26.7%)	3[b] (20.0%)	
30 item[c]	3[b] (20.0%)	3[b] (20.0%)	4[b] (26.7%)	5[b] (33.3%)	
Control					
M	0 (0.0%)	0.6 (0.04%)	0 (0.0%)	0 (0.0%)	
SD	0	0.03	0	0	
Name recognition (out of 15)					
K.C.					
Explicit	13[b] (86.7%)	13[b] (86.7%)	12[b] (80.0%)	12[b] (80.0%)	
Explicit + guess	14 (93.3%)	13[b] (86.7%)	13[b] (86.7%)	13[b] (86.7%)	
Control					
M	14.8 (98.5%)	14.8 (98.5%)	14.9 (99.3%)	14.9 (99.3%)	
SD	0.44	0.44	0.33	0.33	
Name categorization (out of 15)					
K.C.					
Explicit	1[b] (6.67%)	1[b] (6.67%)	1[b] (6.67%)	0[b] (0.0%)	
Explicit + guess	9[b] (60.0%)	8[b] (53.3%)	8[b] (53.3%)	8[b] (53.3%)	
Control					
M	14.9 (99.3%)	14.8 (98.5%)	14.8 (98.5%)	14.9 (99.3%)	
SD	0.33	0.44	0.44	0.44	
Name familiarity (rating out of 7)					
K.C.					
M	5[b]	4.8[b]	4.4[b]	4[b]	1.2
SD	0.44	0.51	0.79	0.75	0.11
Control					
M	6.73	6.76	6.76	6.71	1.34
SD	0.50	0.46	0.28	0.35	0.24
Name matching (out of 15)					
K.C.					
Explicit	7[b] (46.7%)	4[b] (26.7%)	3[b] (20.0%)	3[b] (20.0%)	
Explicit + guess	12[b] (80.0%)	12[b] (80.0%)	10[b] (66.7%)	10[b] (66.7%)	
Control					
M	14.5 (96.7%)	14.5 (96.7%)	14.7 (97.8%)	14.7 (97.8%)	
SD	0.33	0.44	0.44	0.44	
Television and movie matching (out of 10)					
K.C.					
Explicit	6[b] (40.0%)	6[b] (40.0%)	5[b] (33.3%)	5[b] (33.3%)	
Explicit + guess	8[b] (53.3%)	8[b] (53.3%)	7[b] (46.7%)	7[b] (46.7%)	
Control					
M	9.5 (63.5%)	9.5 (63.5%)	9.9 (66.0%)	9.9 (66.0%)	
SD	0.79	0.79	0.89	0.89	

Note. Numbers in parentheses represent percentage of correct scores.
[a] Nonfamous minus famous. [b] K.C.'s performance was more than 2 *SD*s below that of the control group. [c] To determine whether K.C.'s performance on the 30-item word lists was less than 2 *SD*s below the control mean, the score out of 30 was divided by two.

famous names predating his injury (Westmacott & Moscovitch, in press). K.C. was able to pronounce correctly 87% of the famous names from the 1980s and 75–80% of the names from the 1990s; however, his pronunciation of recently famous names was not as good as for remote famous names that entered popular culture prior to 1975 (Westmacott & Moscovitch, in press) and was not as good as controls' pronunciation of recently famous names. Pronunciation errors primarily involved regularization of irregular names (e.g., David Duchovny: "dav-id doo-chove-niye"; Shania Twain: "shan-ee twah-in"); emphasis was placed on the wrong syllable, or silent letters were pronounced. A small number of the pronunciation errors (i.e., one from the 1980s and two from the 1990s) involved distortions at the syllable level (e.g., "Jack Kavanagh" instead of "Jack Kavorkian"). These error data suggest that he is more familiar with recently famous names relative to scrambled nonfamous names but that these recent names are less familiar than remote famous names. Although reading speed and accuracy may be tapping orthographic and phonological

Table 3
K.C.'s and Controls' Performance on the Vocabulary Tasks: Means and Standard Deviations by Time Period

Task and group	1980	1985	1990	1995
Word reading (s)[a]				
K.C.	8.23[b]	7.37[b]	6.04[b]	5.81[b]
Control				
M	17.21	17.42	17.20	17.57
SD	0.70	0.66	0.64	0.81
Word reading (errors out of 15)				
K.C.				
15 item	2[b] (13.3%)	2[b] (13.3%)	4[b] (26.7%)	3[b] (20.0%)
30 item[c]	3[b] (20.0%)	3[b] (20.0%)	4[b] (26.7%)	5[b] (33.3%)
Control				
M	0 (0.0%)	0.6 (0.04%)	0 (0.0%)	0 (0.0%)
SD	0	0.04	0	0
Word recognition (out of 15)				
K.C.				
Explicit	13[b] (86.7%)	12[b] (80.0%)	12[b] (80.0%)	12[b] (80.0%)
Explicit + guess	14 (93.3%)	14 (93.3%)	14 (93.3%)	13[b] (86.7%)
Control				
M	14.9 (99.3%)	14.8 (98.5%)	14.9 (99.3%)	14.9 (99.3%)
SD	0.53	0.61	0.53	0.53
Generating word definitions (out of 15)				
K.C.	6[b] (40.0%)	5[b] (33.3%)	2[b] (13.3%)	2[b] (13.3%)
Control				
M	14.7 (97.8%)	14.7 (97.8%)	13.7 (91.2%)	13.7 (91.2%)
SD	0.50	0.50	0.44	0.50
Choosing word definitions[d] (out of 15)				
K.C.				
Explicit	8[b] (53.3%)	8[b] (53.3%)	4[b] (26.7%)	6[b] (40.0%)
Explicit + guess	11[b] (73.3%)	12[b] (80.0%)	11[b] (73.3%)	10[b] (66.7%)

Note. Numbers in parentheses represent percentage of correct scores.
[a] Pseudowords minus real words. [b] K.C.'s performance was more than 2 *SD*s below that of the control group. [c] To determine whether K.C.'s performance on the 30-item word lists was less than 2 *SD*s below the control mean, the score out of 30 was divided by two. [d] Because control subjects did not perform the second definition task, the control group mean and standard deviation from the task requiring generation of word definitions was used to assess K.C.'s performance in this task.

representations as opposed to true semantic knowledge, these findings do suggest that new information was acquired and retained in some format.

In the name recognition task, K.C. was less able than controls to recognize explicitly the names of individuals achieving fame after the onset of amnesia (performance more than 2 *SD*s below control mean for all time periods). However, when considered relative to chance performance, K.C.'s performance on this task was quite good across all time periods. Specifically, K.C. recognized explicitly more than 80% of the famous names from each of the four time periods postdating his brain injury, and performance increased even further when he was asked to guess. Similarly, K.C. rated famous names from the 1980s and 1990s as more familiar than nonfamous distractor names, but his familiarity ratings for these recently famous names were more than 2 *SD*s lower than the control mean. Moreover, recently famous names were rated as less familiar than famous names from time periods before 1975 (see Westmacott & Moscovitch, in press).

In contrast to his strong performance in famous name recognition, K.C. showed severe impairments in the categorization of famous names; his explicit memory performance on this task approached chance level for all time periods. That is, he was able to recognize explicitly the names of individuals who achieved fame after the onset of his amnesia, but he seemed to possess no specific knowledge about the identities of those famous individuals. The discrepancy between recognition and categorization performance was also found to exist for famous names in the 5-year period just prior to his injury (Westmacott & Moscovitch, in press). However, K.C.'s performance improved when he was asked to guess the correct category for unknown items; he chose the correct descriptor on 55–60% of the trials from all four time periods. K.C.'s explicit memory performance was slightly better in the television and movie matching task; he chose the correct starring actor for 30% of the shows from the early and late 1980s and for 20% of the shows from the early and late 1990s. As in the categorization task, K.C.'s matching of actors with television shows and movies improved when he was asked to guess on unknown items; 80% of the items from the 1980s and 70% of the items from the 1990s were matched correctly. K.C.'s performance in the first–last name matching task was similar, although slightly superior, to that in the television and movie matching task. However, K.C.'s guessing scores were still more than 2 *SD*s below the control mean for almost all time periods across tasks (with the exception of

the 1980s time periods in the television and movie matching task and the 1980–1985 time period in the recognition task).

K.C.'s Postmorbid Knowledge of New Vocabulary Terms

Performance in the vocabulary tasks paralleled that in the famous names tasks. K.C. read real vocabulary words more quickly than scrambled pseudowords in all four time periods, although the difference in reading speed was less pronounced than in controls. Similarly, the difference in reading times for recent words versus scrambled pseudowords was less pronounced than the difference between remote words predating his injury and pseudowords (Westmacott & Moscovitch, in press). K.C. was able to pronounce correctly almost 87% of the words from the 1980s and 70–80% of the names from the 1990s; however, his pronunciation of recent words was not as good as for remote words that came into use prior to 1975 (Westmacott & Moscovitch, in press). As with the famous names, mispronunciations of words primarily involved regularization of irregular word (e.g., El Nino, posse) or transposition of letters (e.g., "laporscapy" instead of "laproscopy").

In the word recognition task, K.C. was less able than controls to recognize explicitly words that came into use after the onset of amnesia, although he performed at the 80% level or above for all time periods. Performance improved further when he was asked to guess. In contrast to his strong performance in word recognition, K.C. performed poorly when asked to provide definitions for recent vocabulary words. He provided correct definitions for 35–40% of the words from the 1980s and for 15% of the words from the 1990s. When he was asked to choose the correct definition in the four-alternative forced-choice task, performance improved only slightly. K.C. recognized explicitly the correct definition for 55% of the words from the 1980s and for 25–40% of the words from the 1990s. When asked to guess on unknown items, K.C.'s performance improved to the 73–80% level in the 1980s and early 1990s and to the 67% level in the late 1990s.

To assess the degree to which K.C.'s explicit memory performance differed between items from the 1980s and the 1990s, we performed a post hoc chi-square analysis. Data were collapsed into two time periods (1980s and 1990s) and across tasks (excluding the reading times tasks); within each time period, the total number of correct explicit responses and the total number of unknown items were calculated. The results indicated that K.C. was significantly more likely to provide correct explicit memory responses for items from the 1980s than for items from the 1990s, $\chi^2(1, N = 16) = 4.31$, $p < .05$. We repeated this procedure using K.C.'s guessing scores instead of his explicit memory scores; there was no evidence to suggest that his implicit memory performance differed significantly between items from the 1980s and 1990s, $\chi^2(1, N = 12) = 2.41$, *ns*. Thus, we found evidence suggesting that K.C.'s postmorbid semantic knowledge is temporally graded when tested using explicit but not guessing measures of memory.

Discussion

K.C., a person with profound amnesia due to extensive bilateral medial temporal damage, demonstrated explicit semantic knowledge of famous names and vocabulary words that entered popular Western culture after the onset of his amnesia in 1981. This new semantic knowledge was explicit and supplemented his implicit memory for famous names and vocabulary words that he demonstrated in his relative reading speed and accuracy, his familiarity ratings, and in his ability to make correct guesses on unfamiliar items. However, his ability to acquire explicit semantic information was impaired relative to control participants, and it appeared to be limited to simple unelaborated semantic, lexical, and orthographic representations, even when tested with recognition paradigms.

Specifically, explicit memory performance exceeded the 80% correct level when K.C. was asked to choose which one of three names was famous or which one of three words was a real vocabulary word. This high level of performance was not the result of correct guessing; rather, these recent famous names and words were recognized explicitly, confidently, and immediately. However, when the task required more detailed elaborate semantic knowledge of the items, as in the famous name categorization, television and movie matching, and word definition tasks, his explicit memory performance decreased dramatically, although it typically remained above chance. This suggests that K.C. has been able to acquire new verbal labels denoting famous individuals and vocabulary words but that these new names and words are poorly associated, if at all, with any specific meaning and are not integrated with previously acquired semantic knowledge.[1] Even a slight modification to the name recognition task, which required subjects to match a famous last name with the correct first name, resulted in a drop in K.C.'s explicit memory performance. This dissociation between the ability to recognize a name or word as familiar and the ability to associate each with a specific meaning supports our argument that performance on tests of postmorbid semantic knowledge depends not only on the type of experimental paradigm (recognition or recall) but also on the specific attributes of the information in question. Furthermore, it suggests that nonhippocampally mediated learning is possible but that it is less flexible and less efficient than hippocampally mediated learning (see discussion below).

K.C.'s performance on tests of postmorbid incidental semantic learning is best accommodated by recent neural network and computational modeling theories of long-term memory that propose that with repeated exposure, some

[1] A similar dissociation between knowledge of verbal labels and their meaning was documented by Papagno and Muggia (1999): A patient with a focal left frontal lesion demonstrated retrograde memory loss for biographical information about famous people and semantic properties of common objects, yet she was able to produce the names of these individuals and objects when presented with photographs. Postmorbid learning was not examined in this patient.

types of new information may be slowly and directly encoded into the neocortex, bypassing the usual stage of initial dependence on hippocampally mediated episodic memory (Alvarez & Squire, 1994; McClelland et al., 1995; Murre, 1997; but see Nadel & Moscovitch, 1997). K.C. is densely amnesic, yet he has been able to acquire some limited semantic knowledge postmorbidly at an explicit level and demonstrates considerable implicit semantic learning. Nonetheless, the knowledge that he has acquired is vague, impoverished, and fragmentary, and his explicit learning appears to be limited to arbitrary perceptual–semantic associations (such as the acquisition of new word-form and name-form representations) as opposed to elaborated relational semantic associations that require integration with existing knowledge structures (Eichenbaum et al., 1994). Consistent with these findings, McClelland et al. (1995) predicted that in the absence of functioning hippocampi, some information may be acquired through direct neocortical learning after many repeated presentations of the information to be learned. Although these authors did not make explicit predictions about the quality of semantic representations acquired by individuals with medial temporal damage, one could argue that because nonhippocampal learning is much slower, it may not permit elaborate relational encoding of new information and integration into existing semantic networks. This, in turn, may result in memory representations that are vague, incomplete, and rudimentary. However, this does not seem to be the case in people whose hippocampal damage occurred early in life (Vargha-Khadem et al., 1997); the semantic memory of these individuals seems normal, although further examination may yet reveal subtle deficits in the rate of semantic acquisition and the quality of semantic representations.

McClelland et al.'s (1995) suggestion that nonhippocampal learning is slow and iterative, requiring many repeated encoding episodes, is supported further by the pattern of recognition performance demonstrated by K.C. across the 20-year period for which he has been amnesic. Although performance exceeded the 80% mark across all postamnesic time periods, K.C. was less likely to recognize explicitly famous names and vocabulary terms from the 1990s as compared with names and words from the 1980s. If nonhippocampal learning requires repeated exposure to stimuli, then one would predict that amnesic patients would show a pattern of temporally graded anterograde memory performance that increases with the remoteness of the information. Presumably, K.C. has been exposed to names and words from the 1980s and early 1990s many more times relative to very recent names and words from the late 1990s. As he encounters these contemporary names and words more and more, one would predict that his performance on these items would increase gradually to the level of earlier time periods.

In the few studies that have examined incidental semantic learning for distinct hemi-decades within the anterograde period, similar temporally graded patterns have been found. Gabrieli et al. (1988) found that patient H.M. was moderately impaired on famous names and vocabulary terms from the 1950s (he became amnesic in 1953) but was severely impaired on names and words from the 1960s on. Similarly, patients P.S. and S.S. performed better on tests of recognition and recall for vocabulary words that entered the language during the most remote anterograde periods relative to words from more recent periods; however, this temporal pattern was not found when famous faces were tested (Verfaellie et al., 2000). One interpretation for this set of findings is that in amnesia, learning of vocabulary and famous names is more likely to occur gradually with repeated exposure to the stimuli than perceptual learning of famous faces because there are more opportunities to encounter names (e.g., in print, in conversation) than faces. However, examination of the control participants' performance in these tasks suggests that the famous faces corresponding to each time period may not have been adequately matched in terms of familiarity and frequency. Control performance was less consistent across time periods and much more variable within time periods for the famous faces tasks relative to the vocabulary tasks. Thus, biased item selection may have prevented the detection of any temporal gradient that exists in the patient's postmorbid memory. As we did not test K.C. on his knowledge of famous faces, it is not possible to determine to what extent these differences in temporally graded patterns of performance are due to individual patient factors or item effects.

The failure to find a significant effect of decade in K.C.'s implicit memory performance may reflect the fact that this analysis had less statistical power; there were fewer total items included in this analysis because some of the tasks had a single performance score and did not include guessing responses (e.g., familiarity ratings, explicit generation of definitions). Another possible explanation is that explicit memory scores in some of the tests (e.g., recognition of names and words) were closer to ceiling level in the 1980s time periods than the 1990s periods, and, therefore, there was less potential for guessing to have a significant facilitative effect in the earlier decade. This argument is consistent with the failure to find an effect of guessing in the controls' performance. Finally, it is possible to interpret this finding as further evidence for the sensitivity of implicit measures to degraded or fragmentary memory representations in brain-damaged individuals. Knowledge of famous names and vocabulary from the 1980s was more intact and more accessible than knowledge of items from the 1990s; however, the degraded representations of these recent names and words are sufficient to guide guessing behavior, thereby minimizing the temporally graded effect. Examination of reading times, another implicit measure, reinforces this interpretation. Like guessing, reading times show no discernible gradient for names and a slight gradient for words. The fact that performance on the reading test is far below normal is another indication of how impoverished these newly acquired lexical representations are.

The possibility that anterograde semantic memory in amnesia follows a temporally graded pattern similar to that found in the retrograde domain warrants further investigation as it may provide unique insight into neural mechanisms mediating postmorbid knowledge acquisition. It is possible, however, that some of the names and words from

the initial postmorbid period were actually encountered during the premorbid period and that the finding of temporally graded anterograde memory was artifactual. These remote items would have been acquired in an intact system and would have benefited from a brief period of hippocampal processing. Although we made an attempt to include in the 1980–1985 time period names and words that entered popular culture well into the 1980s, it is difficult to control for this factor, particularly with respect to vocabulary.

Another possible explanation for the temporally graded pattern in K.C.'s anterograde semantic memory is that his exposure to new information has decreased during the 20 years since his brain injury. If nonhippocampal learning depends on repeated encounters with new concepts, then postmorbid knowledge acquisition should vary with the amount of exposure to media and new sources of information. However, we do not believe that this explanation can account fully for K.C.'s performance given the evidence that semantic dementia patients, although markedly impaired across all time periods, show some preferential sparing of very recent semantic information (e.g., Graham, Pratt, & Hodges, 1998; Hodges & Graham, 1998; Westmacott et al., 2001). Because of their severe verbal comprehension deficits, semantic dementia patients' exposure to new information is at least as restricted as that of amnesic patients, if not more so.

Although K.C.'s explicit memory performance on tasks that required more elaborate semantic knowledge was poor, his performance level improved considerably when his guessing responses were taken into consideration. This significant increase in performance suggested that his guesses were informed by some intact memory representation, possibly at an implicit level. This finding is consistent with the substantial body of research demonstrating intact abilities for implicit anterograde learning in amnesic patients (e.g., Schacter, 1987, 1993) and suggest that amnesic patients may be able to acquire new information and demonstrate it in an implicit manner in the absence of explicit awareness. Furthermore, it highlights the fact that to understand fully the semantic acquisition abilities of amnesic patients, it is necessary to investigate not only which individuals are capable of such learning but also what are the specific properties and qualities of the newly acquired knowledge and how this knowledge differs from that acquired by controls.

It is difficult to make direct comparisons between K.C.'s performance in the present study with that of other patients documented in the literature because previous studies have used considerably smaller stimulus sets and different experimental tasks that did not allow for a distinction between true memory responses and correct guesses. The second performance score calculated (correct explicit memory responses plus correct guesses) is roughly equivalent to the performance measures used in other studies (e.g., Kitchener et al., 1998; Verfaellie et al., 2000). On the basis of these scores, K.C.'s postmorbid semantic learning follows a similar pattern to that of patients R.S. (Kitchener et al., 1998) and P.S. (Verfaellie et al., 2000); performance was best in tasks requiring simple recognition of a stimulus, and declined in tasks requiring uncued recall.

Examination of K.C.'s explicit memory performance scores, however, suggests that semantic acquisition abilities are quite restricted. Explicit memory performance was not only poor for uncued recall (i.e., generating vocabulary definitions) but also for recognition paradigms tapping detailed elaborate semantic knowledge beyond that which is required to make a simple familiarity judgment. For example, K.C.'s explicit memory performance in the famous name categorization task was no better than R.S.'s (Kitchener et al., 1998) performance in the famous name identification task, despite the fact that a recognition paradigm was used to test K.C. and an uncued recall paradigm was used to test R.S. K.C.'s performance exceeded that of R.S. only when K.C.'s correct guesses were taken into consideration. This suggests that semantic acquisition in amnesic patients may be limited by more than poor recall; there may be additional limitations with respect to the amount of detail, elaboration, and flexibility that this new semantic information can sustain. Perhaps nonhippocampal learning is restricted to certain types of associations or representations (e.g., correlational information and simple arbitrary associations may be learned whereas detailed descriptive information cannot), to certain types of learning situations (incidental learning through repeated exposure), or to relatively unsophisticated levels of detail. Recall may be worse than recognition in the majority of amnesic patients because performance in each of these two types of tasks is affected differentially by these factors.

The discrepancy between K.C.'s two performance scores on tests tapping in-depth knowledge of famous individuals and vocabulary terms suggests that unless explicit memory responses are separated from guessing responses, forced-choice recognition paradigms may overestimate the amount of explicit semantic knowledge that has been acquired. Nevertheless, it is possible that this pattern of performance is unique to K.C. and that other patients would not demonstrate this discrepancy between explicit and implicit measures of semantic acquisition. K.C.'s inability to acquire detailed explicit knowledge of vocabulary definitions, famous individuals, movies, and television shows may be due to his unique neuropathological profile. In addition to medial temporal lobe damage, K.C. sustained considerable damage to the left frontal and right occipital regions that may have a detrimental effect on his ability to acquire new semantic information. Moreover, K.C.'s medial temporal damage is much more extensive than that of P.S. and slightly more extensive than that of R.S. The finding of inferior semantic acquisition in K.C. relative to these two patients is consistent with the claim of Vargha-Khadem et al. (1997) and Aggleton and Brown (1999) that the perihippocampal regions are critical for postmorbid learning of factual information. However, it has also been argued that semantic acquisition ability is proportional to residual episodic memory ability, and this may account for K.C.'s particularly poor performance (e.g., Squire & Zola, 1998). Nevertheless, because amnesia tends to be more severe in

patients with more extensive damage, it is difficult to attribute differences in semantic memory acquisition to one factor over the other.

In conclusion, we report the case of a densely amnesic man with a virtually complete loss of autobiographical episodes across his lifetime who is able to recognize famous names and vocabulary words that first entered popular use after he sustained his injury. This recognition ability was temporally graded such that explicit memory performance was better for names and words that entered popular culture soon after the onset of amnesia relative to very recent names and words. Although he could explicitly and confidently identify which names were famous and which words were real vocabulary terms, these labels were not associated with any specific meaning at the explicit level. However, he did show evidence of more detailed semantic knowledge of these names and words on the more indirect measures of memory. It is important to note that although K.C. can recall few personal experiences (and with very little detail) and exhibits a profound episodic learning impairment, his autobiographical memory has not been tested using recognition and implicit memory paradigms such as those used in the present study. K.C. does seem to have acquired some new personal facts (see Westmacott et al., 2001) and, perhaps, he would demonstrate some evidence of new autobiographical learning if tested on tasks comparable with those typically used to examine semantic knowledge. We are currently devising tasks to address this question. Further investigation of amnesic patients with different neuropathological profiles using a range of implicit and explicit tasks promises to clarify how the quality of postmorbid knowledge compares with that acquired by neurologically intact individuals and to uncover the unique contributions of distinct medial and lateral temporal regions to different aspects of semantic acquisition and autobiographical memory formation.

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