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TEMPORALLY GRADED SEMANTIC MEMORY LOSS IN AMNESIA AND SEMANTIC DEMENTIA: FURTHER EVIDENCE FOR OPPOSITE GRADIENTS

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The consolidation theory of long-term memory (e.g., Squire, 1992) predicts that damage to the medial temporal lobes will result in temporally graded retrograde memory loss, with a disproportionate impairment of recent relative to remote knowledge; in contrast, severe atrophy of the temporal neocortex is predicted to result in the reverse temporally graded pattern, with a selective sparing of recent memory (K.S. Graham & Hodges, 1997). Previously, we reported evidence that autobiographical episodic memory does not follow this temporal pattern (Westmacott, Leach, Freedman, & Moscovitch, 2001). In the present study, we found evidence suggesting that semantic memory loss does follow the predicted temporal pattern. We used a set of tasks that tap implicit and explicit memory for famous names and English vocabulary terms from across the 20th century. KC, a person with medial temporal amnesia, consistently demonstrated across tasks a selective deficit for famous names and vocabulary terms from the 5-year period just prior to injury; this deficit was particularly profound for elaborated semantic knowledge (e.g., word definitions, occupation of famous person). However, when asked to guess on unfamiliar items, KC's performance for names and words from this 5-year time period increased substantially, suggesting that he retains some of this knowledge at an implicit or rudimentary level. Conversely, EL, a semantic dementia patient with temporal neocortical atrophy and relative sparing of the medial temporal lobe, demonstrated a selective sparing of names and words from the most recent time period. However, this selective sparing of recent semantic memory was demonstrated in the implicit tasks only; performance on explicit tasks suggested an equally severe impairment of semantics across all time periods. Unlike the data from our previous study of autobiographical episodic memory, these findings are consistent with the predictions both of consolidation theory (Hodges & Graham, 1998; Squire, 1992) and multiple trace theory (Nadel & Moscovitch, 1999) that the hippocampus plays a time-limited role in the acquisition and representation of long-term semantic memories. Moreover, our findings suggest that tasks requiring minimal verbal production and explicit recall may provide a more sensitive and comprehensive assessment of intact memory capacity in brain-damaged individuals.

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Semantic dementia is a neurodegenerative disorder characterised by a multi-modal impairment of semantics that typically develops as the result of bilateral, or left lateralised, atrophy of the anterior, inferior temporal neocortex. The cognitive deficits associated with this disorder extend beyond verbal production and comprehension to include knowledge of objects, facts, concepts, and people; patients appear to be unable to assign meaning to linguistic, visual, or auditory stimuli (Bozeat, Lambon Ralph, Patterson, Garrard, & Hodges, 2000; Hodges, Patterson, Oxbury, & Funnell, 1992; Hodges, Patterson, & Tyler, 1994; Snowden, Goulding, & Neary, 1989). Unlike patients with Alzheimer's dementia, semantic dementia patients with temporal neocortical degeneration do *not* exhibit early, severe anterograde amnesia; rather, they remain well oriented in time and place, and demonstrate reliable day-to-day episodic memory abilities (Graham & Hodges, 1997; Snowden, Griffiths, & Neary, 1996a, 1999). Systematic study of semantic dementia has been conducted primarily in the last decade and many aspects of this disorder remain poorly understood. Nonetheless, investigation of this disorder has provided unique insight into the neuropsychological organisation of long-term memory and the cognitive processes mediating encoding, storage, and retrieval. One reason why this disorder is particularly intriguing, and potentially so informative, is that it is associated with the opposite pattern of neuropathology than that of amnesia; the medial temporal lobe structures that are damaged in amnesia are typically relatively spared in semantic dementia, although some atrophy has been noted (Simons, Graham, Galton, Patterson, & Hodges, 2000; Westmacott et al., 2001). Thus, comparisons between patterns of deficit and preservation in individuals with amnesia and semantic dementia provide a powerful technique for testing hypotheses about the neuropsychological mechanisms underlying long-term memory and new memory acquisition, particularly with respect to the interaction between the structures of the medial temporal lobe and the temporal neocortex.

Early clinical description of semantic dementia (Snowden et al., 1989; Warrington, 1975, 1986) emphasised a selective loss of semantics with a relative sparing of autobiographical memory for personal facts and episodes. However, recent investigations have suggested that the pattern of preserved and impaired abilities in semantic dementia may be less dichotomous and more complex than was thought originally. Specifically, there is a rapidly accumulating body of evidence to suggest that memory recency is an important factor in the deficit patterns exhibited in semantic dementia; patients appear to show a preferential sparing of recently acquired information relative to memories that are more remote (e.g., K.S. Graham & Hodges, 1997; Hodges & Graham, 1998; Murre, Graham, & Hodges, 2001). The hypothesis that long-term memory representations undergo a qualitative change over time has been discussed extensively in the animal and clinical literature. Observations that recently learned information is particularly susceptible to impairment following brain trauma or disease provided strong evidence that memories do not become immediately permanent; rather, there appears to be some period of time following acquisition during which information may be disturbed and prevented from reaching long-term store (e.g., Alvarez & Squire, 1994; Scoville & Milner, 1957; Squire, 1992; Zola-Morgan, Squire, & Amaral, 1986). It is still a matter of controversy whether or not there is more extensive, temporally graded retrograde memory loss following bilateral damage to the medial temporal lobes (as in classic amnesia and Alzheimer's dementia) (see Nadel & Moscovitch, 1997, for review). One purpose of this paper is to examine the nature and extent of retrograde memory loss in amnesia and semantic dementia.

One prominent theory of long-term memory formation postulates the hippocampal complex (including the hippocampus and surrounding parahippocampal, perirhinal, and entorhinal cortices) as a distinct module responsible for acquisition of new memories and their consolidation into a permanent store (e.g., Alvarez & Squire, 1994; Damasio, 1989; McClelland, McNaughton, & O'Reilly, 1995; Squire, 1992; Squire & Zola-Morgan, 1991). Consolidation is thought to be a gradual process necessary for the integration of new information with previously acquired memories in the neocortex. This consolidation theory predicts that focal damage to the hippocampal complex will result in a greater impairment of those memories that remain highly dependent upon these structures, namely, recent memories. In contrast, the reverse pattern of temporally-graded memory loss is predicted in semantic dementia; because the hippocampal tissue preserves recently acquired information, and the neocortex mediates consolidated memories, remote memories should be disproportionately impaired relative to recent memories (e.g., K.S. Graham & Hodges, 1997; Hodges & Graham, 1998).

This prediction received support from recent findings of *reverse* temporally graded memory loss in semantic dementia with a disproportionate impairment of remote relative to recent memory for famous names and public events, as well as for some types of autobiographical information (e.g., K.S. Graham & Hodges, 1997; K.S. Graham, Lambon Ralph, & Hodges, 1997; K.S. Graham, Pratt, & Hodges, 1998; Hodges & Graham, 1998; Snowden et al., 1996a). Knowledge of past and contemporary famous names has been assessed in semantic dementia patients using recognition, matching, and identification tasks (K.S. Graham & Hodges, 1997; Hodges & Graham, 1998; Snowden, Griffiths, & Neary, 1995; Warrington, 1996). Semantic memory was found to remain relatively more intact for famous personalities from contemporary and recent time periods (i.e., within the last 5 years) than for personalities associated with more remote periods. Memory loss for public events has also been found to follow a temporally-graded pattern. K.S. Graham et al. (1998) report a semantic dementia patient who was better able to recognise and describe historical events from a verbal cue (e.g., "The Windsor Castle fire," "The Mars Pathfinder landing") when those events were from recent, as opposed to remote, time periods.

However, one potential problem with these findings of reverse temporally graded memory loss in semantic dementia is that the tasks employed in these studies tended to rely heavily upon verbal comprehension and expression and on effortful strategic recall (e.g., provide detailed information about a famous individual, a famous event, or a personal friend from a short verbal cue). These types of tasks may not be appropriate for investigating semantic dementia because these patients have severe deficits in verbal comprehension and production and can be quite unresponsive during testing. Consequently, it is difficult to establish a clear temporal gradient in memory loss using these tests due to confounding floor effects[1]: Patients' performance on tests of semantic memory is typically extremely poor, thereby decreasing the probability that any existing effect of recency will be detected. Moreover, any indication of a temporal gradient in performance on these verbally-demanding tasks cannot be assumed to be reliable (Chertkow & Bub, 1990; Milberg, 1996). Thus, in order to obtain the most sensitive, accurate measure of preserved and impaired memory abilities in patients with semantic dementia, it may be necessary to lower the demands of testing by choosing tasks that require minimal verbal comprehension and expression and minimal effort in retrieval.

The need for modified testing and scoring criteria was highlighted in a recent study examining autobiographical episodic memory in an advanced stage semantic dementia patient (Westmacott et al., 2001). Instead of relying on verbally demanding tests such as the Autobiographical Memory Interview (Kopelman, Wilson, & Baddeley, 1990) and the Crovitz technique (Crovitz & Schiffman, 1974), as most previous studies have done, we examined autobiographical episodic memory using family photographs as recall cues. In addition to using visual, as opposed to verbal, cues for recall, we also employed a scoring system that neither depended upon accurate, fluent verbal descriptions, nor on the ability to provide specific names of people and places. Rather, responses were evaluated according to the degree to which they suggested the existence of an intact experiential representation, or a sense of "remembering" (Tulving, 1989). By

[1] Of note, patient DM (K.S. Graham et al., 1998; Hodges & Graham, 1998) did not perform at floor and still exhibited this reverse step-function pattern in his performance.

minimising the verbal and strategic recall demands of the task, we were able to demonstrate remarkably preserved recent and remote autobiographical episodes in our patient that were not detected initially using other standardised measures. In contrast to the global sparing of autobiographical episodes demonstrated by EL, KC demonstrated global retrograde and anterograde amnesia for this type of memory. Moreover, although EL was not able to recognise explicitly any famous names, when asked to read a list of famous and nonfamous names out loud he did show evidence of some preserved knowledge that was degraded and not readily accessible; on some of the famous items he hesitated, repeated the name several times, and/or made a comment that he should know who the person is. He did not do this for any of the nonfamous names (Westmacott et al., 2001). Because the findings from our earlier study were not consistent with the predictions of consolidation theory, we wanted to determine whether EL and KC would show a similar ungraded pattern of performance on tests of semantic memory or the predicted temporally-graded pattern. Moreover, these previous findings suggested the need to develop implicit or indirect measures of remote semantic memory to examine further the nature of this patient's memory loss.

The goal of the present study was to explore further the possibility of temporally-graded retrograde memory loss in our amnesic patient, KC, and of a reverse gradient in our semantic dementia patient, EL (Westmacott et al., 2001), by extending the use of techniques that are minimally dependent upon verbal production and explicit recall to the study of general semantic memory. K.S. Graham et al. (1997) and Snowden, Griffiths, and Neary (1994) adopted a similar approach but used fewer, less varied tasks relative to the present study, and did not examine the temporal gradient hypothesis. There is evidence from research into amnesia, Korsakoff's syndrome, and Alzheimer's dementia that patients' performance on tests of anterograde and retrograde memory improves as task difficulty is decreased. For instance, performance on tests of matching and recognition of famous names and faces is typically much better than performance on tests requiring explicit identification, description, or naming of such personalities (e.g., Greene & Hodges, 1996b; Hodges & Graham, 1998; Snowden et al., 1995). Similarly, performance improves when patients are provided with prompts or cues to aid in memory retrieval; naming of famous personalities is much better if patients are given the first letter or syllable of the name, or if they are required to match first and last names in a multiple-choice procedure (e.g., Warrington, 1986, 1996; Warrington & McCarthy, 1988).

These findings of an effect of task difficulty also suggest that employing a variety of tasks that range along the explicit-implicit continuum may allow for a more sensitive and comprehensive measure of intact memory ability in individuals with brain damage or disease (Moscovitch, 1984; Murre, 1997; Schacter, 1987, 1993, 1996). Implicit memory involves an unintentional, automatic form of encoding and retrieval that is thought to operate largely at an unconscious level. Explicit memory, in contrast, requires conscious information processing during encoding and retrieval and is associated with purposeful, strategic behaviours (Schacter, 1993, 1996). Studies employing implicit paradigms such as speeded reading, lexical decision, semantic priming, and preference ratings (e.g., Elliot & Dolan, 1998; Moscovitch, 1994; Schacter, 1985; Shimamura, 1986) have found evidence of preserved anterograde memory abilities that failed to be detected using tasks requiring more explicit recognition or identification procedures (e.g., naming, matching, recognition, identification, and free recall tasks). However, there has been little research examining the explicit-implicit continuum with respect to remote memories. (Murre, 1997; but see K.S. Graham, Patterson, & Hodges, 1995, and Lambon Ralph & Howard, 2000, for examples of implicit memory tasks used with semantic dementia patients.)

The rationale for the present use of implicit tests and tests of familiarity to examine the hypothesis of temporally graded memory loss is further supported by the observation that the responses produced by memory-impaired patients on experimental tasks frequently take on a somewhat implicit quality (e.g., Hodges & Graham, 1998; Warrington, 1996). For instance, patients may subjectively feel a sense of familiarity when confronted with a given stimulus without being able to access any conscious memories pertaining to that stimulus. Similarly, patients may report that they probably *would* have been able to identify a particular stimulus at some point in the past, but that they no longer have any knowledge of it (e.g., K.S. Graham & Hodges, 1997; Hodges & Graham, 1998; Warrington, 1996). Moreover, patients are often unaware when they have given a correct answer (Snowden et al., 1995). These reports suggest that experimental tasks designed to tap implicit retrograde memory and familiarity in semantic dementia may provide a more sensitive method for evaluating the reverse temporal gradient hypothesis than tests of recognition and identification. Furthermore, the use of indirect memory assessment tasks would allow for the extension of the implicit-explicit dimension of memory to the retrograde literature, and the examination of unaddressed questions regarding incidental, implicit learning through repeated, real-life exposure to information following medial temporal lobe damage.

Finally, a comprehensive evaluation of retrograde memory integrity requires the use of a variety of stimuli and a variety of tasks designed to assess the many distinct aspects of semantic memory, including lexical knowledge. Therefore, in the current study we expand upon previous work on semantic memory loss in semantic dementia and medial temporal lobe amnesia not only by incorporating a wider range of experimental tasks with reduced verbal demands, but also by including explicit and implicit tasks designed to tap knowledge of remotely and recently acquired English vocabulary terms.

EXPERIMENT 1: KNOWLEDGE OF FAMOUS NAMES

Person-related semantic memory was assessed for remote and recent time periods using a series of experimental tests that tap knowledge of past and contemporary famous personalities. Designed specifically in order to evaluate the hypotheses of the present study, these tasks varied along the implicit-explicit continuum with respect to the type of cognitive processing required for performance. Participants began with memory tests involving implicit processing (speeded reading and pronunciation) and progressed through a series of tasks placing increasingly greater demand upon explicit memory (recognition, categorisation, first-last name matching, actor-TV show matching, familiarity rating). To eliminate confounding factors present in previous studies, all of the experimental tasks were designed to place little demand on the strategic processing abilities and verbal production skills of the participants.

Tests assessing knowledge for famous names (and also famous faces) have been used extensively in psychological research for several decades, and are generally regarded to be valid methods for assessing remote semantic memory function (e.g., Bahrick, Bahrick, & Wittlinger, 1975; Chertkow & Bub, 1990; Greene & Hodges, 1996a; Warrington, 1996). In comparison to other types of semantic knowledge (e.g., general factual information; knowledge specific to a given academic discipline), it is much easier to test knowledge of famous individuals as this is a valid body of knowledge that is "culturally shared" and likely to be possessed by the vast majority of the population (Hodges & Graham, 1998; Warrington, 1996; Warrington & McCarthy, 1987, 1988). A further advantage of using tests of famous names in order to assess semantic memory is that it is possible to examine the effect of memory recency and the hypothesis of temporally-graded impairment. Famous individuals may be associated with a given time period from the past during which they were portrayed most often in the media; performance on tests of memory subsequently may be compared across time periods. In contrast, it is virtually impossible to determine at what point in time many other types of semantic knowledge (e.g., encyclopaedic facts) would have been acquired (Bahrick et al., 1975; Milberg, 1996).

Method

Participants

The present study focused upon the semantic memory abilities of two memory-impaired individuals: An advanced-stage semantic dementia patient, EL, and a medial temporal lobe amnesic patient, KC. The case histories and neuropsychological profiles of these two patients have been described in detail in a recent paper exploring their autobiographical memory abilities (Westmacott et al., 2001).

EL is a 66-year-old, right-handed man. He received 10 years of formal education in England and worked as a graphic designer/illustrator for a media corporation. He was forced to stop work in 1996, after a 2-year period of progressive memory and verbal communication difficulties accompanied by severe depression. The results of a neuropsychological assessment performed in 1999 indicate that EL's verbal comprehension and production abilities are severely compromised yet his nonverbal cognitive skills remain well preserved. He is clearly aware of his cognitive difficulties; he reports that he often forgets words and people's names and is no longer able to comprehend things that he reads. Despite his apparent loss of word knowledge, his speech was fluent and grammatical. Word-finding problems were very apparent in his conversational speech but often he was able to explain in sufficient detail the word or concept that he was trying to express. His wife also reports that he appears to remember recent events and that he does not repeat tasks or repeatedly ask questions. Magnetic resonance imaging (MRI) performed in January 1997 and April 2000 revealed radiological findings consistent with cortical degeneration characteristic of semantic dementia (MRI scan presented in Westmacott et al., 2001). Cerebral atrophy was most noticeable in the anterior temporal region, particularly on the left side; the hippocampus appeared slightly smaller on the left. There was evidence of encephalomalacia in the subcortical white matter of the left anterior temporal lobe and evidence of an arachnoid cyst in the region of the anterior and inferior temporal lobe on the left.

In contrast to patient EL, KC has amnesia with preserved semantic memory. KC is 47 years old and has completed 15 years of formal education. He has been tested extensively over the course of the nearly 20 years since becoming amnesic after a motorcycle accident in October of 1981. MRI and computerised tomography (CT) scans illustrating the specific loci of brain damage suffered by KC have been documented elsewhere (e.g., Rosenbaum et al., 2000; Tulving, 1989; Tulving et al., 1988). KC suffered almost complete bilateral destruction of the hippocampus in addition to a right occipital lesion and a left fronto-parietal lesion. There is also some evidence of bilateral parahippocampal atrophy. In a 1996 neuropsychological assessment, KC 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 WMS-R: his General memory score is 61, his Verbal scale score is 67, and his Visual scale score is 69. KC performs poorly on tests of recognition memory for words and faces; however, his naming abilities and perceptual abilities remain well within the range of normal.

Each patient's performance was contrasted with a separate matched control group. Control group 1 consisted of 12 subjects, 6 male and 6 female, matched with EL in terms of age ($M = 62.4$ yrs), ethnic background (white Anglo-Saxon), education ($M = 11.5$ yrs), and handedness (right). Control group 2 consisted of six male subjects matched with KC in terms of age ($M = 46$ yrs), ethnic background (white Anglo-Saxon), education ($M = 19$ yrs) and handedness (right). None of the subjects included in either control group had any sign of neurological, medical, or psychological impairment. Data were collected during several separate testing sessions over the course of 5 months. Finally, upon completion of data collection, written feedback was provided regarding the rationale and predictions of the present study.

Materials

The stimulus set consisted of 480 names of famous people gathered from a wide range of 20th century historical literature sources (Aaker, 1997;

Commire, 1994; Gann, 1997; P. Graham, 1968; Soderberg, Washington, & Press, 1977; Stein, 1977; Ziegler, 1990). The names were grouped according to the 5-year time period within which they first became famous. An attempt was made 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 twelve 5-year time periods from 1940 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., Gregory Peck, Meryl Streep, Celine Dion); athletics (e.g., Mickey Mantle, Bjorn Borg, Shaquille O'Neil); politics (e.g., John F. Kennedy, Yasser Arafat, John Major); and miscellaneous (e.g., Neil Armstrong, Paul Bernardo, Monica Lewinsky). An individual's nickname was utilized in lieu of his/her real name if it was judged that the majority of media and public references to that individual involved use of the nickname (e.g., Magic Johnson). In addition, a large set of distracter items was constructed using non-famous names representing the same range of nationalities as the experimental stimuli.

Several other factors were taken into consideration during construction of the stimulus set. First, famous individuals were chosen with the cultural background of the focal subject in mind. EL was born in England and moved to Canada as a teenager; therefore, individuals experiencing fame in North America or England were considered for inclusion in the stimulus set. Second, famous personalities from the most recent time periods (i.e., late 1980s to the present) were chosen carefully in light of the age of the participants; that is, an attempt was made to include only those names that would probably have been encountered by older adults (Hodges & Graham, 1998; Warrington, 1996). Third, in order to avoid some of the confounds present in previous studies, an attempt was made to equate the individuals within each time period with respect to familiarity or degree of fame. Familiarity is a critical factor that must be controlled if valid inferences regarding temporally-graded memory loss are to be made. Although the possibility of confounding was informally investigated by testing the materials in pilot studies, equation of familiarity across time periods was evaluated more precisely by including familiarity ratings as one of the experimental tasks. Finally, the present study utilised a much larger stimulus set than has been used in previous studies, and included individuals who have achieved fame through a very wide range of activities. These two factors promised to help increase the reliability and the construct validity of the stimuli.

Experimental tasks

Reading time for famous names vs. scrambled names. Fifteen famous names from each of the twelve 5-year time periods were selected from the original stimulus set for inclusion in the reading time task. Each of the four categories (arts, athletics, politics, and miscellaneous) was represented in the set of famous names chosen for each time period. A comparison set of 15 nonfamous names was constructed 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, due to the fact that last names alone often carry the designation of "famous" (e.g., Stallone, Schwartzenegger), 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, three practice lists, each consisting of 15 nonfamous names, were constructed from the set of distracters; there was no overlap between the practice items and the experimental items. Participants were asked to read out loud each list of names as quickly and accurately as possible. Reading time, in seconds, was recorded for each list using a stopwatch. Participants' reading accuracy and the ease with which each list was read were noted also. Difference scores were calculated for each time period by subtracting the mean reading time for famous names from the mean reading time for nonfamous names.

Reading time has been used in prior studies as a measure of implicit memory (e.g., Goshen-Gottstein & Moscovitch, 1995; Moscovitch, Winocur, & McLachlan, 1986). Presumably, reading time will be faster for names that are already represented within semantic memory than for novel names that must be sounded out according to the grapheme-phoneme correspondence rules of the English language (Shallice & Saffran, 1986). This has been illustrated by the finding that, in normal subject populations, familiar words and names are typically read faster than unfamiliar ones. Therefore, if the performance of memory-impaired patients is better for a given list of famous names than for its corresponding list of scrambled names, it will suggest that some knowledge acquired during that specific time period remains intact—at least in terms of its lexical representation. Differences in reading times between each pair of famous and scrambled lists then may be compared across time periods in order to assess the temporal gradient hypothesis. There is considerable debate regarding the contribution of semantic knowledge to reading aloud; performance of this task may primarily depend upon phonological and orthographic information and may not require input from the semantic system (e.g., Cipolotti & Warrington, 1995; Raymer & Berndt, 1996; Strain, Patterson, & Seidenberg, 1995). In this paper, we use the term "semantic" to refer to a type of declarative memory that differs from "episodic" memory with respect to time and context dependency. We acknowledge, however, that our use of the term semantic is very broad and includes knowledge about meaning, phonology, and orthography.

Recognition of famous names in a three-alternative forced-choice task. The same set of famous names utilised in the reading time task was utilized for the name recognition task. Each of these 180 famous names was paired with two nonfamous names matched with respect to gender and ethnicity. These nonfamous distracter 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. These 180 name triplets were presented to subjects one at a time and in random order. Subjects were told that only one of the three presented names belonged to a famous individual and were asked to identify which one it was by pointing to the appropriate name. Accuracy was recorded for each trial, but subjects did not receive any feedback regarding their performance.

Participants were required to provide an answer for each trial; if they were unsure of the correct response, participants were asked to "guess." This modified forced-choice procedure was used in each of the semantic tasks in Experiments 1 and 2 of the present study in order to avoid problems of response bias and subjective criterion placement. A response of "I don't remember" may reflect a loss of access to that information or a loss of the memory trace itself; however, it may simply reflect the willingness of the subject to judge that a cognitive experience is, in fact, associated with true memory (Reingold & Toth, 1996). In cases where the status of the name or vocabulary term is ambiguous, subjects rely on a subjective criterion to decide the degree of familiarity necessary to establish confidence that the memory is real. Furthermore, studies of implicit memory suggest that subjects are often unaware of memories that do exist and that influence performance of experimental tasks. One way to circumvent this problem is to use a forced-choice procedure such as the one adopted in the present study (Reingold & Toth, 1996). This technique promised to increase the sensitivity and reliability of the experimental tasks in assessing intact semantic knowledge. On each trial, subjects were asked to indicate if their responses were guided by the retrieval of specific memory representations or if they were simply guessing. Guessing responses were recorded separately from true memory responses in order to permit a comparison between performance on explicit tasks and tasks that tapped both conscious and unconscious processing (Reingold & Toth, 1996).

Recognition tasks such as the one employed here have been used in several studies investigating semantic memory for famous individuals (e.g., K.S. Graham et al., 1997; Greene & Hodges, 1996a; Hodges & Graham, 1998; Kapur, 1993). Although this task does require explicit processing and recall, it does not place a high demand on verbal comprehension or verbal production abilities. Memory-impaired patients have been found to demonstrate better performance on recognition tests of semantic memory than on tests that require free-recall, explicit identification, or production of comprehensive verbal descriptions (e.g., Hodges & Graham, 1998; Snowden et al., 1995; Warrington & McCarthy, 1992). Thus, the recognition task described here promises to provide a more sensitive measure of semantic memory function than many of the more explicit techniques utilised in prior studies.

Classification of famous names by category. The same set of 180 famous names was utilised in the famous name classification task. Each name was 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. Participants were asked to point to the category descriptor that best fit the famous individual.

The classification task taps explicit memory function and also places a somewhat heavier demand on verbal proficiency than the tasks presented thus far. However, although this task may demand greater proficiency in verbal comprehension skills and vocabulary, it does not require the type of sophisticated verbal response that is required by identification and description tasks used in previous studies (e.g., K.S. Graham et al., 1997; Hodges & Graham, 1998). Therefore, it was judged that this task was appropriate for the assessment of semantic memory function in semantic dementia patients. Furthermore, this task permitted the evaluation of remote semantic memory for information regarding famous individuals that is more detailed and elaborate than simple name recognition.

Matching of famous last names with the correct first names. Fifteen famous names from each time period, representing each of the four descriptive categories, were selected from the original stimulus set for inclusion in the matching task. This set of famous names was completely nonoverlapping with respect to the set utilised in the four previous tasks in order to ensure that the task was tapping remote memory and not simply recognition of previously presented experimental items. These famous first name-last name pairs were subsequently 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. Alternate first names were chosen in such a way as to match the correct first name with respect to gender and nationality/ethnicity. On each trial, subjects were presented with a famous last name (e.g., Kennedy) and were asked to choose the correct first name from a set of three possibilities (e.g., Bill, David, John). If the subject was unsure of the correct answer, she or he was asked to guess; explicit recognition and guessing responses were scored separately. Accuracy was recorded for each trial, but no feedback was provided to subjects regarding their performance.

As with the recognition task, the matching task requires some explicit cognitive processing; however, it does not require proficiency in verbal comprehension or production. This lack of reliance on intact verbal function suggests that this task provided an appropriate technique for assessing the memory abilities of semantic dementia patients. Similar matching tasks have been used in studies with other memory-disordered populations and have been found to facilitate performance on tests of retrograde memory (e.g., McCarthy & Warrington, 1992; Warrington, 1996; Warrington & McCarthy, 1992). However, no such task had been applied to the study of semantic dementia.

Matching movies or television programmes with the correct actor. This task utilised a novel set of stimuli. One hundred and twenty titles of motion pictures or television programmes were selected for inclusion in the matching task; 10 movie/television show titles dating from each of the 12 time periods. In addition, each title was matched further with the names of two other famous individuals: 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), while the other 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/television show titles were presented individually and in random order. Participants were asked to select, from a choice of three alternatives, the name of the actor starring in the movie or television programme. Accuracy was recorded for each trial, although no feedback was provided to participants.

The actor–TV show (or movie) matching task was designed to permit evaluation of the variety of semantic knowledge preserved in memory-impaired patients, and to explore the degree to which this knowledge remains elaborated. That is, matching the names of actors with the appropriate movie or television show title presumably requires more extensive semantic knowledge than tasks focusing on name recognition. No known studies to date have used this specific technique of assessment, although knowledge of Hollywood movies and television programmes has been assessed in other ways as a measure of semantic memory function (e.g., Bahrick et al., 1975; Squire & Slater, 1975). Even though this task requires a moderate amount of linguistic knowledge, it requires less verbal production ability than previously employed tasks (e.g., Hodges & Graham, 1998).

Familiarity ratings of famous and nonfamous names. The same set of 180 famous names employed in the recognition and categorisation tasks was utilised in the familiarity ratings task; also included were 180 of the nonfamous names utilised as distracter items in the famous name recognition task. These 360 names were arranged in random order and presented to participants as a typed list. Participants were asked to read each name and to indicate its degree of subjective familiarity by circling the appropriate number on a 7-point rating scale (where 1 = completely unfamiliar, and 7 = extremely familiar).

The familiarity ratings task provided a measure of construct validity and a measure of response bias, in addition to providing a measure of the strength and integrity of memories acquired at a given point in the past. If the mean familiarity ratings provided by the control groups are roughly equivalent across the different time periods, it would indicate that degree of fame was adequately controlled in constructing the stimuli, and it this factor did not confound the experimental findings. Furthermore, familiarity ratings for nonfamous names provided an indication of the participant's readiness to rate names as familiar; an average rating for nonfamous names that is significantly higher than "1" (or the control group average rating of nonfamous names) suggests that the participant's performance is confounded by response bias. Importantly, as with the two previous experimental tasks, familiarity ratings require explicit cognitive processing but rely relatively little on verbal ability (Hodges et al., 1995; Hodges & McCarthy, 1995; Hodges & Patterson, 1995).

Results and discussion

Performance of the two patients and two control groups (means and standard deviations) in the speeded name reading task are presented by time period in Table 1; patients' performance scores that are more than 2 *SD*s below the control group mean are indicated by an asterisk (*). The semantic dementia patient, EL, was unable to perform the name recognition, name categorisation, name matching, familiarity ratings, and television/movie tasks. He could not recognise explicitly a single famous name in the entire stimulus set and his severe verbal impairment prevented him from understanding the guessing instructions. Therefore, only data from the reading times task are presented for EL. Data from KC and all control

Table 1. *Patients' and controls' performance on the names and words reading tasks—means and SDs by time period. Asterisks (*) indicate patient's performance is more than two standard deviations below that of the control group*

Task	*1940*	*1945*	*1950*	*1955*	*1960*	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*1995*
1. Speeded reading of names (s)												
EL												
Famous	25.87	26.16	28.12	27.31	27.32	28.69	29.56	28.71	26.94	25.51	24.18	22.14
Nonfamous	27.46	28.09	28.29	28.36	28.28	28.97	30.24	30.39	28.57	29.76	28.33	28.71
Difference	*1.59	*1.93	*0.17	*1.05	*0.96	*0.28	*0.68	*1.68	*1.63	4.25	4.15	6.57
Control 1												
Famous	11.41	10.43	11.31	10.86	10.68	9.43	11.25	11.71	10.53	10.01	11.40	11.11
Nonfamous	16.63	16.07	16.54	16.21	16.51	15.38	16.74	16.99	15.71	15.31	16.85	16.60
M difference	5.77	5.64	5.23	5.35	5.83	5.95	5.49	5.28	5.81	5.30	5.45	5.94
SD difference	1.27	1.04	0.83	1.14	1.33	0.98	0.49	0.55	1.07	1.02	1.06	1.25
KC												
Famous	21.74	20.99	17.33	17.25	16.98	17.03	16.35	17.84				
Nonfamous	23.56	23.37	21.84	22.92	22.9	22.88	22.65	22.05				
Difference	1.82	2.38	*4.51	*5.41	*5.92	*5.85	6.23	*4.21				
Control 2												
Famous	13.1	12.93	9.49	9.67	9.13	10.02	9.81	9.22				
Nonfamous	14.83	14.67	15.51	15.95	16.02	16.84	16.57	16.00				
M difference	1.73	1.74	6.02	6.48	6.89	6.82	6.76	6.78				
SD difference	0.85	0.65	0.71	0.52	0.44	0.47	0.84	0.61				
2. Reading errors of famous mames												
EL (15-item)	*10	*11	*9	*10	*9	*11	*9	*10	*11	*9	*5	*3
EL (30-item)[a]	*23	*27	*22	*25	*20	*24	*23	*21	*23	*26	*18	*4
Control 1												
M	0.8	0.7	0	0	0	0.4	0.3		0.5	0.2	0.7	0.7
SD	0.1	0.04	0	0	0	0.01	0.01	0	0.01	0.01	0.04	0.04
KC (15-item)	0	0	0	0	0	0	0	*1				
KC (30-item)[a]	0	0	0	0	0	0	0	0		*1		
Control 2												
M	0	0	0	0	0	0	0	0				
SD	0	0	0	0	0	0	0	0				
3. Speeded reading of words (s)												
EL												
Real words	21.21	22.43	21.60	23.56	22.52	24.86	23.03	23.78	23.33	20.64	20.41	19.07
Pseudowords	22.80	24.36	21.77	24.61	23.48	25.14	23.71	25.46	24.96	24.89	24.56	25.64
Difference	*1.59	*1.93	*0.17	*1.05	*0.96	*0.28	*0.68	*1.68	*1.63	*4.25	*4.15	6.57
Control 1												
Real words	9.11	8.53	8.67	9.31	10.45	10.42	9.88	9.23	10.24	10.68	9.53	9.97
Pseudowords	19.31	18.80	18.83	19.58	20.61	21.19	20.16	19.55	20.45	20.79	19.79	20.69
M difference	10.20	10.27	10.16	10.27	10.16	10.77	10.28	10.32	10.21	10.11	10.26	10.14
SD difference	0.79	1.07	0.67	0.64	1.15	1.33	0.68	1.17	0.80	1.69	1.74	1.88
KC												
Real words	17.94	17.93	17.43	16.94	13.1	13.19	12.76	13.95	18.03	17.93	18.36	18.73
Pseudowords	27.48	28.79	27.76	28.29	28.07	27.21	26.32	22.08	26.26	25.3	24.4	24.54
Difference	9.54	10.86	*10.42	11.05	*14.07	*14.02	*13.56	*8.13				
Control 2												
Real words	12.04	11.79	11.59	11.38	9.05	9.18	8.92	8.12				
Pseudowords	22.67	22.32	24.10	24.09	26.03	26.25	26.08	25.65				
M difference	10.63	10.53	12.51	12.81	16.98	17.22	17.16	17.53				
SD difference	1.38	1.08	1.12	1.01	1.44	1.36	1.29	1.47				
4. Reading errors of words												
EL (15-item)	*12	*11	*12	*13	*10	*13	*11	*11	*12	*13	*11	*6
EL (30-item)	*28	*26	*28	*27	*26	*26	*24	*27	*28	*23	*20	*13
Control 1												
M	0	0	0	0	0	0	0	0	0.6	0.6	0.6	0.6
SD	0	0	0	0	0	0	0	0	0.04	0.04	0.04	0.04
KC (15-item)	0	*1	0	0	0	0	0	*1				
KC (30-item)	0	*2	*1	0	0	0	0	*4				
Control 2												
M	0.6	0.6	0	0	0	0	0	0				
SD	0.04	0.04	0	0	0	0	0	0				

[a]To determine whether or not the patient'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 2.

*Performance more than 2 *SD*s below that of the control group.

subjects are presented for each of the seven tasks in Experiment 1 (Table 2). In addition, due to the high levels of explicit memory performance, 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. The second performance score—explicit recognition plus correct guesses—is presented for KC only. Because KC 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, because we wanted to focus exclusively upon KC's retrograde amnesia (and not his anterograde memory abilities), data from this patient and control group 2 are presented for the 1940-1980 time periods only. KC's anterograde memory for famous names and vocabulary words that came into popular use after the onset of his amnesia has been investigated in a separate study using tasks identical to those used here; findings suggest that KC has been able to acquire some new knowledge of famous names and vocabulary words at a lexical level, but that these new lexical concepts have little explicit semantic meaning associated with them (Westmacott & Moscovitch, 2001).

EL's knowledge of famous personalities

The reading times data for EL were contrasted with those of control group 1; reading times for the famous names list and the nonfamous names list as well as the difference score are presented in Table 1. Control subjects demonstrated a consistent effect of fame in their reading times across all time periods; that is, they were consistently faster in their reading of famous names as compared to scrambled names. EL demonstrated a temporally graded pattern with respect to reading times difference scores (Figure 1a); he seems to possess more knowledge about very recently famous names than about those from remote time periods. The difference in EL's reading times for nonfamous and famous names was in the range of normal for the most recent time period (1995–present) only. EL showed little effect of fame in his reading times for famous names from any of the other periods, although the effect did increase markedly in the 1985–1989 and 1990–1994 time periods (performance was between 1 and 2 *SD*s below the control mean).

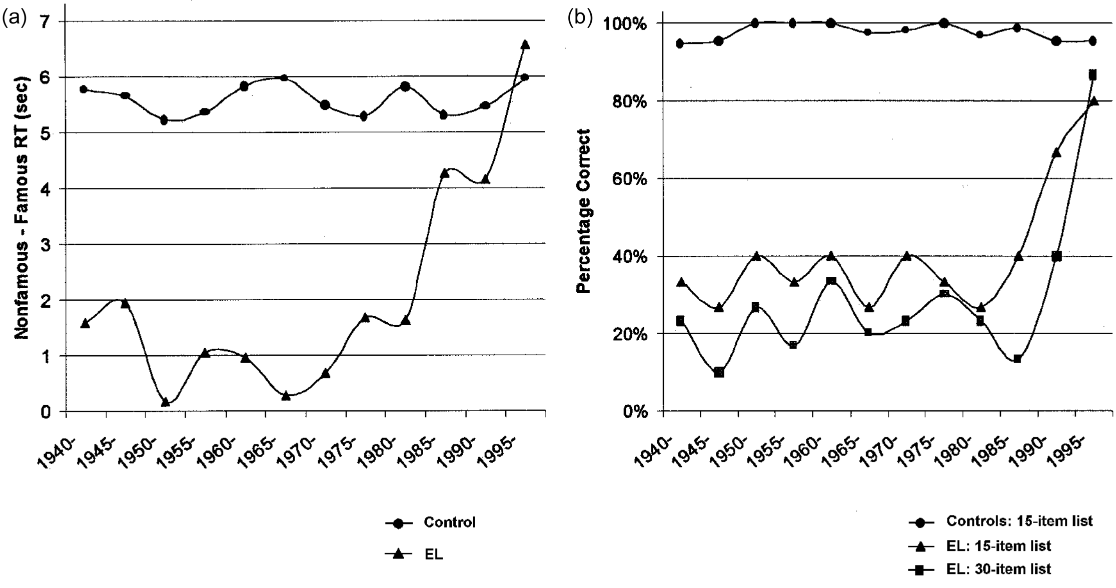

Figure 1. *(a) Differences in EL's and control subjects' reading times, in seconds, for scrambled and famous names from 1940 to the present. (b) Percentage of famous names pronounced correctly by EL and control subjects in the reading times task.*

Table 2. *KC's and controls' performance on the explicit memory tasks—famous names and vocabulary words by time period*

Task	*1940*	*1945*	*1950*	*1955*	*1960*	*1965*	*1970*	*1975*	*Fillers*
1. Name recognition/15									
KC									
Explicit	9	9	13	15	15	15	15	*13	
Exp + guess[a]	10	11	13	15	15	15	15	15	
Control 2									
M	10.22	11.11	12.56	13.89	14.67	14.67	14.67	14.78	
SD	1.09	1.48	1.13	0.60	0.50	0.58	0.50	0.44	
2. Name categorisation/15									
KC									
Explicit	8	8	14	14	15	15	*5	*3	
Exp + guess	9	9	15	14	15	15	14	*11	
Control 2									
M	9.11	9.78	13.00	13.78	14.78	14.78	14.78	14.89	
SD	0.85	0.98	0.87	0.67	0.44	0.44	0.44	0.60	
3. Name familiarity/7									
KC									
M	3.4	3.8	6.4	6.8	6.8	6.8	6.6	*5	1.2
SD	0.35	0.44	0.58	0.50	0.21	0.21	0.32	0.28	
Control 2									
M	3.64	3.84	6.00	5.93	6.62	6.80	6.62	6.69	1.34
SD	0.48	0.41	0.41	0.24	0.48	0.32	0.41	0.30	0.24
4. Name matching/15									
KC									
Explicit	10	11	10	12	15	15	15	*10	
Guess	11	11	12	14	15	15	15	*13	
Control 2									
M	10.22	10.78	12.11	13.67	14.67	14.67	14.78	14.89	
SD	1.56	0.87	1.45	1.27	0.76	0.83	1.04	0.81	
5. TV/Movie task/10									
KC									
Explicit	4	5	6	8	10	9	9	*5	
Exp + guess	5	5	7	8	10	9	9	9	
Control 2									
M	4.78	4.78	5.89	8.78	9.44	9.44	9.78	9.56	
SD	0.97	0.67	0.78	1.09	0.53	0.53	0.44	0.73	
6. Word recognition/15									
KC									
Explicit	12	13	13	15	15	15	15	*13	
Exp + guess	14	14	14	15	15	15	15	14	
Control 2									
M	12.78	13.44	13.89	14.11	14.78	14.78	14.78	14.78	
SD	1.09	0.78	1.13	0.60	0.50	0.50	0.59	0.65	
7. Word definition/15									
KC	13	13	14	15	15	15	15	*11	
Control 2									
M	9.78	10.89	12.22	13.11	14.44	14.56	14.56	14.56	
SD	1.20	0.60	1.09	1.05	0.53	0.53	0.73	0.73	

[a]Exp + guess refers to the second performance score, which included correct explicit responses and correct guesses. The number of incorrect guesses can be calculated by subtracting this score from the maximum possible score in the category.

*KC's performance more than 2 *SD*s below that of the control group.

The pattern shown in the error data from this task is consistent with the reading times data (Table 1). Control subjects made very few errors in their pronunciation of famous names and showed no effect of time period. In contrast, EL was much less likely to make pronunciation errors when reading famous names from the two most recent time periods relative to famous names from any of the more remote time periods (Figure 1b). Interestingly, despite the fact that EL could not recognise any of the famous names explicitly, he pronounced correctly 80% of the names from the 1990–1994 period and almost 70% of the names from the current time period. Moreover, many of these correctly pronounced recently famous names had irregular spellings and did not follow the grapheme-phoneme correspondence rules of the English language; the fact that these names were not affected by his surface dyslexia suggests that EL retains some degree of knowledge of these famous individuals (although it is not clear whether this knowledge is semantic or episodic in nature). In order to obtain a more reliable measure of famous name pronunciation, an elongated list consisting of 30 famous names was created for each time period by combining the items from the name recognition and first–last name matching tasks. EL was asked to read through the list as quickly and accurately as possible and his pronunciation errors were noted. As with the shorter lists, EL made fewer pronunciation errors on names from the most recent time period; more than 85% of these famous names were pronounced correctly. However, in contrast to the 15-item version of the task, EL did not show evidence of preferentially preserved knowledge for famous names from the 1990-1994 time period, as he pronounced only 40% of these names correctly. However, due to the fact that controls made very few pronunciation errors, EL's performance on this measure was more than 2 *SD*s below the control mean across all time periods for both the 15-item and 30-item lists.

Thus, EL appeared to demonstrate a reverse temporal gradient in his semantic memory loss with respect to famous names. This effect appears to apply most strongly to famous names from the present time period, although it may extend to names from the most recent decade under some circumstances. However, it must be noted that this pattern of reverse temporally-graded memory loss was demonstrated in the implicit processing task only. Performance on the explicit memory tasks is more consistent with the conclusion that knowledge of famous personalities was profoundly impaired across the patient's entire lifetime. This discrepancy between performance on implicit and explicit tasks suggests that the distinction between these two types of processing may be applicable to the understanding of remote memory. Furthermore, these data suggest that semantic dementia patients may retain a substantial amount of information at the implicit level even when explicit access to this information is severely impaired due to extensive neocortical atrophy[2].

KC's knowledge of famous personalities

KC's performance in each of the six memory tasks, including pronunciation error data from the reading time task, was compared with that of control group 2 (Tables 1 and 2; Figures 2 and 3). Similar to control group 1, the younger control group demonstrated a consistently high level of performance across remote and recent time periods in each of the six experimental tasks. However, the younger control group demonstrated a drop in performance for famous names from the 1940s and early 1950s consistently across all six tasks. Not surprisingly, this suggests that the younger control subjects were less familiar with the names of individuals who were famous prior to their birth as compared to those achieving fame after 1960.

KC demonstrated this same depression in performance with respect to famous names from the 1940s and 1950s. Moreover, he demonstrated a dramatic increase in performance beginning with the 1960s time period, paralleling the performance of controls. KC's performance level remained high through to the 1975–1979 time period just prior to the onset of his amnesia. Significantly, the point at

[2] It is also possible that EL's performance in the reading times task reflects memory at an explicit level that has become so severely degraded that it can only be accessed indirectly.

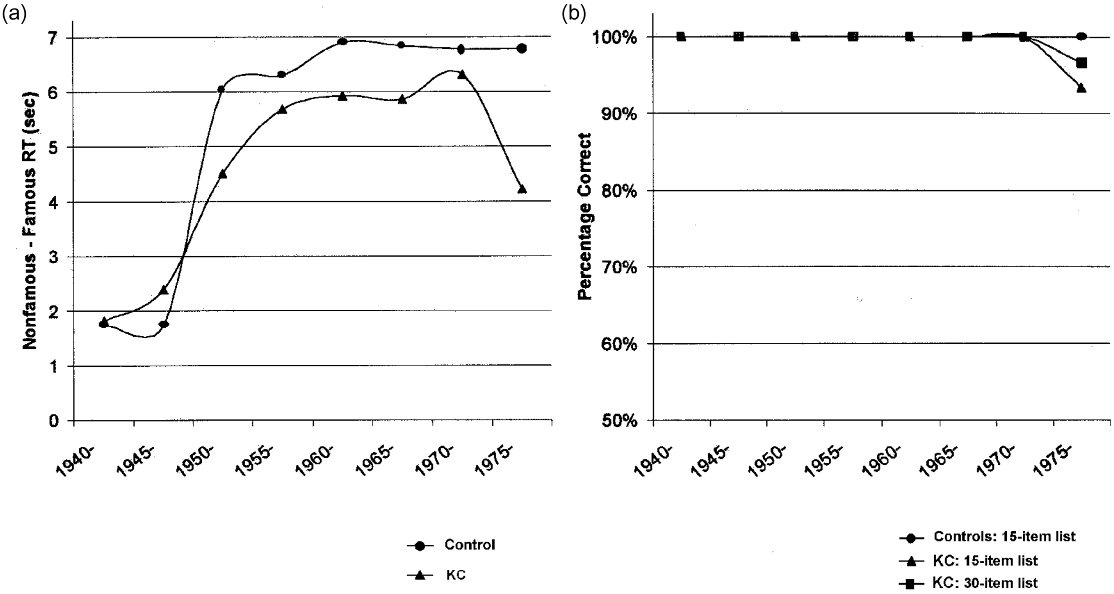

Figure 2. *(a) Differences in KC's and control subjects' reading times, in seconds, for scrambled and famous names from 1940 to the onset of amnesia in 1980. (b) Percentage of famous names pronounced correctly by KC and control subjects in the reading times task.*

which performance suddenly declined was consistent across all six experimental tasks. These data suggest a pattern of temporally graded retrograde memory loss for famous names, with a disproportionate impairment of knowledge acquired in the 5-year period just prior to injury.

When asked to guess the correct answer for unknown items, KC demonstrated much higher levels of performance for names in the 1975–1979 time period. Guessing performance for names in this time period was much higher than explicit performance in the name recognition task, the name matching task, and the TV/movie task (although performance was still more than 2 *SD*s below the control mean in the name matching task). Moreover, although performance on items from the retrograde period of loss improved with guessing, it still remained below the level of explicit recognition demonstrated for more remote periods. This finding is consistent with the reading time data; KC's reading of famous names from the 1975-1980 period was faster than his reading of scrambled names, but this difference was less pronounced relative to the 1960-1975 time periods (Figure 2a). These data suggest that some information acquired just prior to the onset of amnesia is represented in memory and may be accessible at an implicit level, as when the subject is asked to guess, even when it ceases to be available to conscious, explicit memory[3]. Furthermore, the finding of a decreased effect of fame in reading time for the 1975–1980 period suggests that retrograde memory loss in amnesia does not simply reflect an inability to access previously stored information; rather, it suggests that this information was not completely consolidated prior to brain injury and that the memory trace itself exists in an incomplete, degraded form.

[3] The fact that guessing did not improve KC's performance on the name categorisation task may suggest that this type of elaborate, detailed semantic knowledge is more susceptible to disruption by MTL damage, and that representations are lost so that they are not accessible, even at an implicit level.

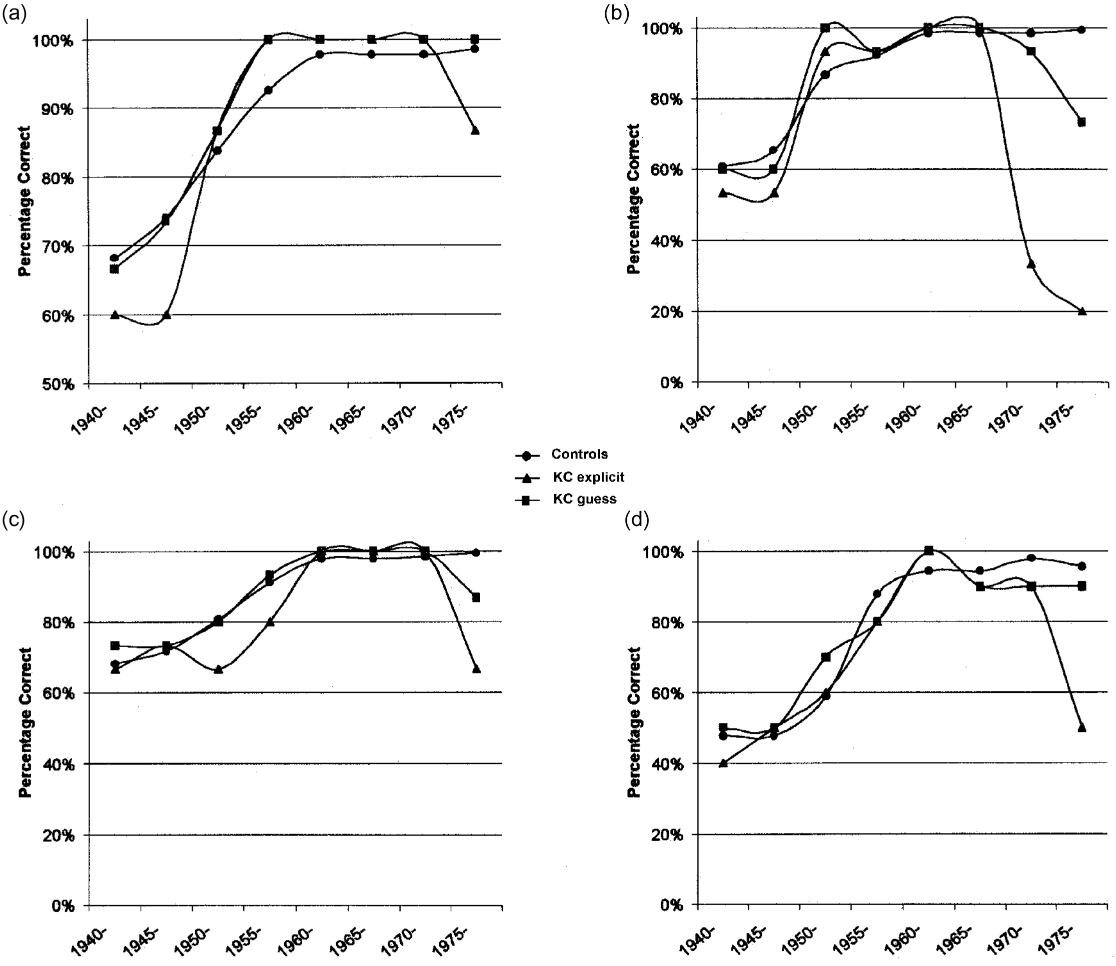

Figure 3. *(a) Percentage of famous names recognised explicitly and guessed correctly by KC in a three-alternative forced-choice task. (b) Percentage of correct famous name categorisations made by KC, explicitly and through guessing, in a three-alternative forced-choice task. (c) Percentage of correct famous first–last name matchings made by KC, explicitly and through guessing, in a three-alternative forced-choice task. (d) Percentage of correct matchings between famous names and movies/TV shows made by KC, explicitly and through guessing, in a three-alternative forced-choice task.*

EXPERIMENT 2: KNOWLEDGE OF NEW WORDS IN THE ENGLISH VOCABULARY

General semantic memory, not related to knowledge for people, was assessed for remote and recent time periods using a series of experimental tests that tapped knowledge of new words and terms that have entered the English vocabulary in the 20th century. Similar to the assessment of person-related knowledge in Experiment 1, the tasks in Experiment 2 were designed to tap general semantic knowledge that varied along the implicit-explicit information processing continuum and relied relatively little upon verbal ability. Participants began with involving strictly implicit processing (speeded reading and pronunciation) and progressed through a series of tasks that placed increasingly greater demand upon explicit recall (recognition, definition).

Tests assessing vocabulary knowledge have been used extensively in psychological research with memory-impaired populations and they are generally regarded to be valid methods for assessing remote semantic memory function (e.g., Chertkow & Bub, 1990; K.S. Graham & Hodges, 1997; K.S. Graham et al., 1997; Greene & Hodges, 1996a; Verfaellie, Reiss, & Roth, 1995; Warrington, 1986, 1996). Tests of English vocabulary terms possess the same two methodological advantages discussed previously with respect to tests of famous individuals.

First, a test based on vocabulary terms may be devised such that it consists of "culturally shared" information common to most individuals in any given society. Furthermore, by determining the time period during which the term entered the English vocabulary, it is possible to evaluate the hypothesis of temporally graded memory loss (Kapur, 1993; Warrington, 1986, 1996; Warrington & McCarthy, 1987, 1988). No known studies to date have examined temporally graded semantic memory loss for vocabulary terms in patients with semantic dementia.

Method

Participants

The participants in Experiment 2 were the same patients and control groups as used in Experiment 1.

Materials

The stimulus set consisted of 360 English words, or vocabulary terms, gathered from a wide range of encyclopaedic sources (Algeo, 1991; Ayto & Simpson, 1992; Barnhart, 1994; Cherry Lane Music Company, 1995; Gozzi, 1990; Oxford University Press, 1996, 1997; Soukhanov, 1995; Young, 1993). The words were grouped according to the 5-year time period within which they were judged to have officially entered the English language. Each of the 5-year time periods from 1940 through to the present day contained a total of 30 English terms; these terms contained single or multiple words, and came from either the slang or formal English vocabularies. The words included in this set were chosen such that they were appropriate for participants with a North American, and specifically Canadian, background. In addition, a large set of distracter items was constructed using pronounceable nonwords (i.e., pseudowords). It was critical to ensure that these nonwords follow the phonemic and grammatical rules of English due to findings of preserved phonological and grammatical ability in semantic dementia (e.g., Patterson, Graham, & Hodges, 1994). If any of the nonword terms were in obvious defiance of these structural rules, then this information could be used by participants to perform the tasks.

Experimental tasks

Reading time for real words vs. scrambled words. Fifteen English vocabulary terms from each of the twelve 5-year time periods were selected 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 comparison 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. Reading time, in seconds, was recorded for each list using a stopwatch. Participants' reading accuracy and the ease with which each list was read were also noted. Difference scores were calculated for each time period by subtracting the mean reading time for real words from the mean reading time for pseudowords. As with the famous names, an elongated list consisting of 30 vocabulary terms per time period was created.

Recognition of English words in a three-alternative forced-choice task. The same set of 180 English vocabulary terms utilised in the reading times task was employed in the word recognition task; each vocabulary term then was paired with two pseudowords. These groups of three were presented to subjects one at a time and in random order. Subjects were told that only one of the three terms was an actual English word and were asked to identify it by pointing manually. Accuracy was recorded for each trial, but subjects did not receive any feedback regarding their performance. As in Experiment 1, if the subject was unsure of the correct response, he or she was asked to "guess" in order to avoid the problem of response bias and to provide the most sensitive measure possible of intact memory. Explicit and guessing responses were scored separately.

Providing definitions or descriptions of English vocabulary terms. For each of the English vocabulary terms identified correctly in the forced-choice recognition task, the participant was asked 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 employ a forced-choice paradigm and null responses were accepted.

Results and discussion

Performance by the two patients and two control groups (means and *SD*s) in the speeded words reading task are presented by time period in Table 1; patients' performance scores that are more than 2 *SD*s below the control group mean are indicated by an asterisk (*). The semantic dementia patient, EL, was unable to perform the word recognition and word definition tasks. He could not recognize any of the vocabulary terms included in the stimulus set and his severe verbal impairment prevented him from understanding the guessing instructions. Therefore, only data from the reading times task are presented for EL. Data from KC and all control subjects are presented for each of the three tasks. As in Experiment 1, only levels of explicit memory performance are presented for the control groups. The second performance score—explicit recognition plus correct guesses – is presented for KC only. As in the first experiment, KC did not make any *incorrect explicit responses;* therefore, 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, scores for KC and control group 2 are presented for the 1940–1980 time periods only.

EL's knowledge of English vocabulary terms

The reading times data for patient EL were contrasted with those of control group 1; reading times for real words and pseudowords, as well as the difference score, are presented in Table 1. Control subjects were consistently faster in their reading of real words as compared to pseudowords across all time periods. In contrast, EL demonstrated a temporally-graded pattern of semantic memory loss in that he seemed to be more familiar with words that had just recently entered the English language than with those dating from remote time periods (Figure 4a). The difference in EL's reading times between real words and pseudowords was in the range of normal solely for the most recent time periods (i.e., 1995–present and possibly 1985–1994). EL showed little evidence of distinguishing between real words and made-up words from any of the more remote time periods. The error data were consistent with the reading times data; EL pronounced correctly approximately 60% of the words from the current time period, but less than 35% of the words from any of the more remote time periods (Figure 4b). Thus, EL appeared to demonstrate a reverse temporal gradient in his semantic memory for vocabulary terms, paralleling the performance pattern demonstrated in the famous names reading time task. However, it must be acknowledged that this evidence of reverse temporally graded memory loss in semantic dementia comes exclusively from implicit tasks. Performance on the explicit tasks is more suggestive of an equally severe impairment of lexical knowledge across the temporal continuum.

KC's knowledge of English vocabulary terms

KC's performance on the reading time, word recognition, and word definition tasks are contrasted with that of control subjects in Tables 1 and 2. Resembling performance patterns from Experiment 1, control group 2 demonstrated a consistent

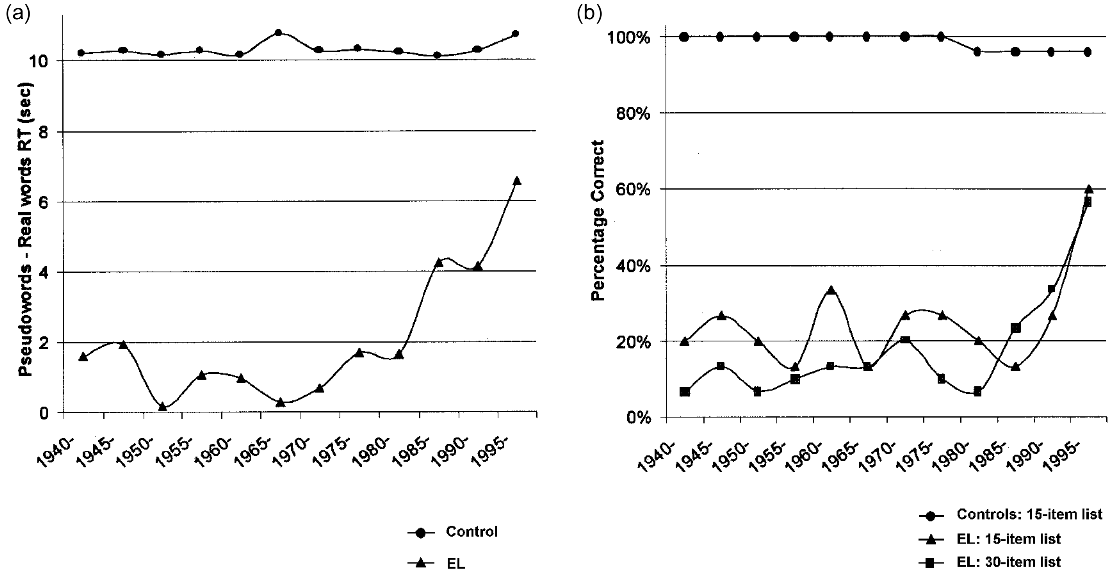

Figure 4. *(a) Differences in EL's and control subjects' reading times, in seconds, for scrambled pseudowords and English vocabulary terms from 1940 to the present. (b) Percentage of vocabulary terms pronounced correctly by EL and control subjects in the reading times task.*

effect of word type on reading time across remote and recent time periods, with the exception of the 1940s and 1950s. Control subjects also demonstrated near-perfect performance on word recognition and definition for all items subsequent to the 1955–1960 time period. This suggests that the younger control subjects were less familiar with the vocabulary words that were popular prior to their birth as compared with more recent words.

KC demonstrated this same depression as controls in performance levels for vocabulary terms from the 1940s and 1950s (Figures 5 and 6). Moreover, KC's performance resembled that of controls with respect to the sudden increase in performance to near-perfect levels for vocabulary terms beginning with the 1960 time period. KC continued to demonstrate relatively normal performance on vocabulary terms through to the 1975–1980 time period just prior to the onset of amnesia. When asked to guess on unknown items from this time period, KC's performance in the word recognition task improved (Figure 6a), although his performance in the word definition task did not (Figure 6b). As in the famous names reading task, KC read real words faster than pseudowords across all time periods, but this difference was much less pronounced in the 1975–1980 period. Again, this suggests that retrograde memory loss in amnesia cannot be entirely accounted for by a failure in retrieval of previously acquired information.

GENERAL DISCUSSION

Overall, the findings from Experiments 1 and 2 are consistent with those reported previously (e.g., K.S. Graham et al., 1998; Hodges & Graham, 1998; Murre, Graham et al., 2001) and with the hippocampal consolidation theory (e.g., Squire, 1992) insofar as it is applied to the long-term storage of semantic memory. Consistently across all experimental tasks, the person with amnesia, KC, demonstrated temporally-graded retrograde memory loss for famous personalities and vocabulary terms; names and words from the 5-year time period just prior to his injury were disproportionately impaired relative to items from any of the more remote time periods. This is consistent with the consolidation theory claim that because recently acquired semantic memories remain

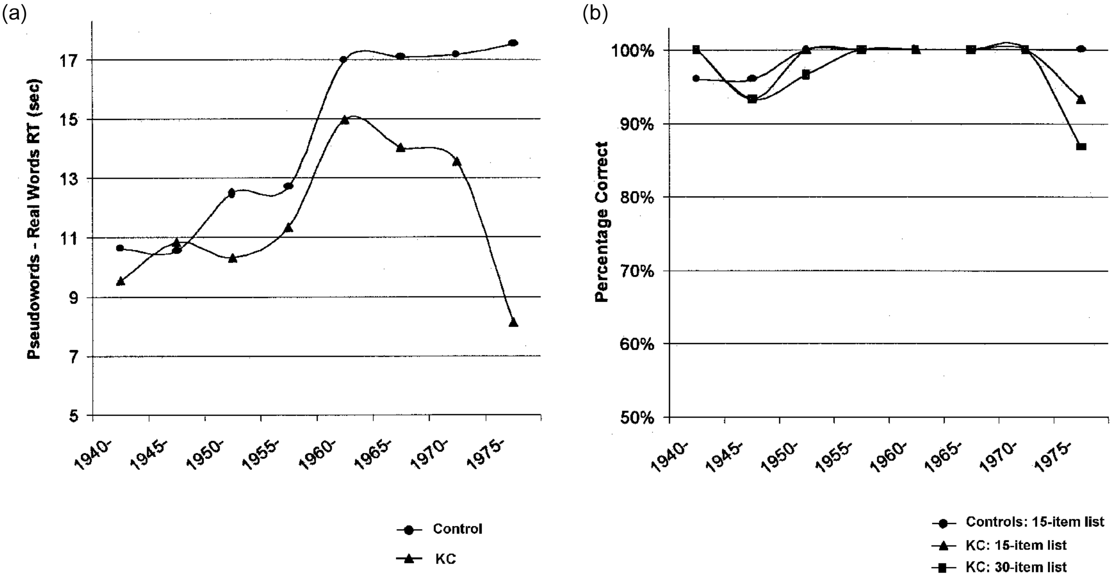

Figure 5. *(a) Differences in KC's and control subjects' reading times, in seconds, for scrambled pseudowords and English vocabulary terms from 1940 to the onset of amnesia in 1980. (b) Percentage of vocabulary terms pronounced correctly by KC and control subjects in the reading times task.*

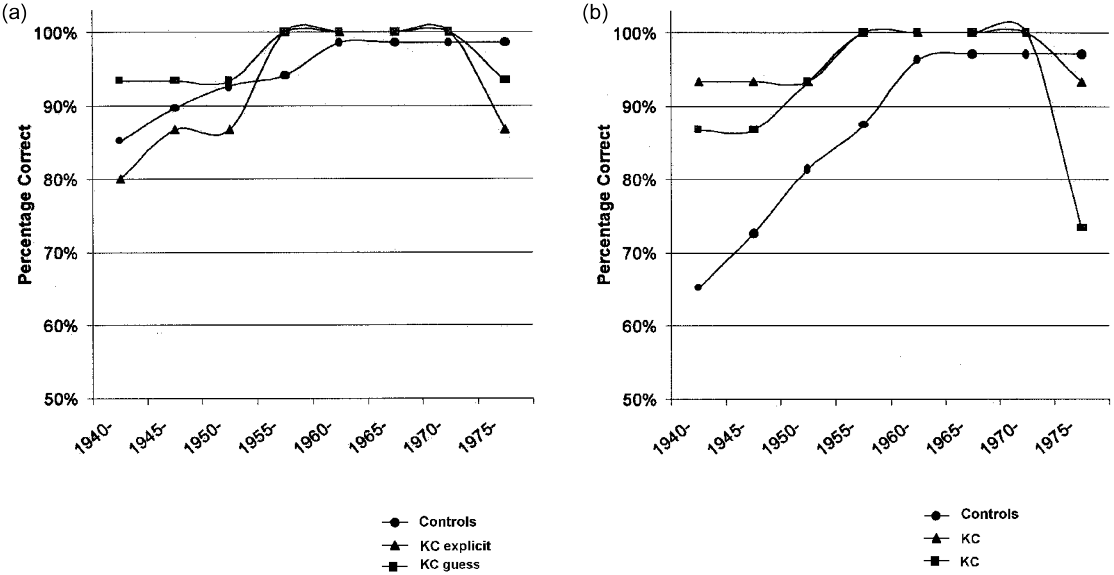

Figure 6. *(a) Percentage of vocabulary terms recognised explicitly and guessed correctly by KC in a three-alternative forced choice task. (b) Percentage of vocabulary terms recognised explicitly and defined correctly by KC.*

hippocampally-dependent, they are likely to be disproportionately impaired following medial temporal lobe damage. In contrast, remote semantic memories are less vulnerable to damage because they have become consolidated into the neocortex and exist independently of the hippocampal complex.

Conversely, the semantic dementia patient, EL, was so severely impaired with respect to knowledge of famous names and vocabulary terms that he was unable to perform most of the experimental tasks. Nonetheless, the limited amount of data that was obtained from this patient in the reading times tasks provided evidence of a reverse pattern of temporally graded semantic memory loss such that very recent names and vocabulary terms were better preserved than remote items. This pattern is consistent with the consolidation theory's prediction that patients with severe neocortical atrophy will show an increased reliance upon the medial temporal lobe memory system and, consequently, a preferential sparing of recently acquired information. However, this prediction was not confirmed definitively, as the patient did not demonstrate this pattern consistently; this preserved knowledge of recent famous names and vocabulary terms was demonstrated at the implicit level only. EL's performance on the explicit memory tasks provided no evidence for a reverse temporally graded semantic loss; rather, his performance was suggestive of a profound deficit in person-related and lexical semantics across the temporal continuum. Due to the fact that performance on explicit tasks was confounded by floor effects, it is difficult to draw conclusions regarding temporally-graded patterns of memory loss in this patient. This prediction has received stronger support in studies by Hodges, Graham, and colleagues (e.g., K.S. Graham & Hodges, 1997; K.S. Graham et al., 1998; Hodges & Graham, 1998; Murre et al., 2001); however, research into semantic dementia is in its infancy and further investigation is required before this reverse pattern of temporally graded loss may be established conclusively. It may be most useful to study individuals who are in the early stages of semantic dementia, as it is more likely that any existing gradient could be detected in such patients.

We should note, however, that although the evidence presented in this paper is consistent with consolidation theory, it should not be construed that it supports consolidation theory over its competitors. The limited, temporally graded memory loss applies only to semantic memory. The consolidation theory predicts similar effects for autobiographical episodic memory. However, in our previous study (Westmacott et al., 2001), we found that KC's retrograde amnesia for autobiographical episodes extended back to childhood, whereas autobiographical episodes were remarkably preserved in EL across the lifespan. Taken together, the findings from these two studies are more in line with multiple trace theory (MTT), which posits different patterns of retrograde amnesia for autobiographical and semantic memory (Moscovitch & Nadel, 1998, 1999; Nadel & Moscovitch, 1997). Briefly, according to MTT, the hippocampal complex, in conjunction with the neocortex, is needed to retain and recover autobiographical memories, whether they are recent or remote. Semantic memory is more neocortically dependent, requiring the hippocampal complex for temporary support only. The semantic memories that are retained are those that have some autobiographical significance and, therefore, may benefit from continued hippocampal involvement (Westmacott et al., 2001; see also Snowden et al., 1996a). Typically, these memories are the more recent ones, though this need not always be the case (see following).

Time of acquisition vs. autobiographical significance

An alternative explanation for findings of reversed temporally graded memory loss in semantic dementia, which is consistent with MTT, has been proposed by Snowden et al. (1996a, 1999). They argue that preferential sparing of contemporary famous names and recent public events is not due to the recency of acquisition per se; rather, it is due to the fact that such recent information is more likely than remote information to be relevant to the individual's current autobiographical experience. These researchers suggest that in semantic dementia, autobiographical experience becomes an organising principle around which all knowledge is structured, and that personal significance is critical in determining which pieces of semantic information remain partially intact. This interaction between personal experience and semantic integrity is evidenced in patients who are able to use words in conversational speech that they cannot comprehend out of context in experimental tasks, and who only retain bits of information about how objects relate to their personal lives, such as their own vase or furniture, while losing general knowledge about the same objects if they are unfamiliar and have no personal relevance (Snowden et al., 1994, 1995, 1996a, 1999). Moreover, there is evidence that semantic dementia patients are better able to recognise, identify, and match the names of personally relevant individuals as compared to celebrities, and are better at identifying and localising places that they have visited personally compared to unvisited places (Snowden et al., 1994, 1995; Westmacott et al., 2001). Finally, our semantic dementia patient, EL, showed greater familiarity with famous names that were easily remembered in the context of a specific episode by a group of age-matched controls in a remember/know task, regardless of whether the memories were recent or remote, as predicted by MTT (Westmacott et al., 2001).

This explanation assumes that autobiographically significant semantic information is represented and structured differently from semantic information that is not relevant to the self. Snowden et al. (1999) have argued that autobiographically significant information is more widely distributed throughout the temporal and parietal neocortex in relation to nonrelevant, abstract semantic concepts that are localised largely in the inferior temporal regions. We have suggested that autobiographically significant semantics—what we have termed "personalised semantics"—continue to depend partially upon the hippocampal complex, whereas nonpersonal semantics become hippocampally-independent after the consolidation process is complete (Westmacott et al., 2001). These two views are compatible if one assumes that widely distributed memory traces have more complicated representations and, therefore, continue to depend upon hippocampal activity for their reconstruction at the time of recall. Thus, when the anterior, inferior temporal cortex becomes severely atrophied, as in semantic dementia, autobiographically significant memories, whose representations extend outside of this region, are more likely to remain partially preserved; as a result, semantic knowledge becomes fragmented, selective, and highly constrained by personal experience. Though not derived from MTT, this explanation is certainly consistent with it.

The hypothesised interaction between autobiographical significance and semantic integrity is an intriguing one and there is some very compelling, albeit preliminary, evidence in its support. However, there is also a compelling body of evidence, which includes our present findings, to suggest that recency of acquisition is critical in determining semantic integrity. It is not clear that all of these data can be accounted for by assuming that recently learned information is necessarily more significant to one's autobiographical experience than remote knowledge (see Graham et al., 1999, for a challenge to Snowden et al.'s argument). For example, there is no reason to assume that the recently developed vocabulary terms used in the present study are more relevant to EL's daily experiences than old vocabulary words, yet he performed better with recent words in the reading time task. Many of these recent words pertain to computers and information technology, neither of which is particularly significant to EL's personal experiences. Similarly, there is no reason to assume that recently famous names are more personally relevant to EL than older names; in a recent study in which control subjects were asked to rate famous names in a remember/know task, we found no indication that recently famous names were more likely than remote names to be recalled within the context of a specific episode (Westmacott et al., 2001). Thus, there is substantial evidence to suggest that the pattern of preserved and impaired semantic knowledge demonstrated by semantic dementia patients is influenced by both recency and autobiographical significance. One way to interpret these findings is that recent names and words are likely to be associated with many more episodic details relative to remote items. With time, these details are lost or forgotten, resulting in a more semanticised memory that is less hippocampally dependent. Autobiographically significant facts, names, or words may be an exception to this general pattern of semanticisation over time. These memories may be more likely to be repeatedly recalled in the context of an entire episode, making them continually dependent upon the temporal-spatial information provided by the hippocampal complex. Future studies might address the interaction of these two factors upon semantic integrity by exploring possible differences in performance for autobiographically significant and nonsignificant recently learned information.

Implicit remote semantic memory

A secondary goal of the current study was to explore the distinction between implicit and explicit levels of processing with respect to retrograde memory. The current consensus is that medial temporal lobe damage results in a disproportionate impairment of recently acquired memories because these new traces still depend upon the hippocampal complex to bind together the individual neocortical units involved in the initial processing of the information. Thus, it may be argued that medial temporal lobe damage does not completely destroy recently acquired memories; it simply renders them consciously inaccessible (Moscovitch, 1994). If this hypothesis is correct, then one might predict that recent semantic memories, unable to be recalled explicitly, are still represented in the neocortex in fragmentary form, and that they may influence performance during implicit memory tasks. Anterograde implicit learning and memory have been demonstrated clearly in amnesic patients in experimental settings; however, implicit semantic memory for remote knowledge has not been explored thoroughly.

We assessed implicit memory for person-related and general semantics by comparing reading times for real words and real famous names with reading times for fictitious words and fictitious names, and by examining the extent to which participants could guess correctly in a series of explicit memory tests (see K.S. Graham et al., 1995, and Lambon Ralph & Howard, 2000, for examples of other implicit tests used with semantic dementia patients). Whereas reading speed may be considered an implicit test since memory is not assessed directly, guessing has elements of both implicit and explicit tests. On the one hand, the participant denies conscious awareness of the correct answer while guessing, but on the other hand, guessing resembles a forced-choice recognition test that, ostensibly, is explicit. Overall, control subjects did not demonstrate qualitatively different patterns of performance on the implicit and explicit measures, nor did guessing improve performance. It is possible, however, that ceiling effects on the explicit tasks prevented detection of any additional implicit processing; control performance was so high that there was very little, if any, room for improvement. Thus, with respect to control subjects, our findings are not illuminating regarding the explicit/implicit distinction for remote semantic memory. More sensitive tests may be needed for use with neurologically intact individuals.

However, the semantic dementia patient, EL, did demonstrate differential patterns of performance on the implicit and explicit memory tests. In fact, the only indication that any semantic knowledge remained intact in this patient was the finding of faster reading times for real words and famous names from the present time period as compared to fictitious words and names. This suggests that tasks capitalising on implicit processing are more sensitive than highly explicit tasks as measures of spared semantic memory in neuropsychological patients. Moreover, it implies that implicit tasks have the potential to uncover weak or partially intact memory representations that otherwise might go unnoticed. We argue that the preferential sparing of memory for recent famous names and words in EL is due to his hippocampal sparing; the fact that this recently acquired knowledge was demonstrated at the implicit level only may reflect the severity of his temporal neocortical atrophy. Although the hippocampal complex insulates recent memories from impairment in semantic dementia, these memory traces will still become fragmented if their corresponding neocortical traces have degraded completely.

Most interestingly, KC, the person with amnesia, did demonstrate evidence of intact implicit representations for names and words that were not recognised explicitly. On tasks for which explicit memory performance declined during the period of retrograde loss, guessing improved KC's performance significantly. Although he claimed to be purely guessing, the significant increase in performance level suggested that his guesses were informed by some memory representations that were accessible only via tests that have a considerable implicit component. 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 suggests that the implicit/explicit distinction is relevant to the study of retrograde (semantic) memory. His performance on the reading times task, however, indicates that although these representations can guide guessing behaviour, they are clearly degraded. Thus, the reading task reflects residual knowledge in EL when all other performance measure fail; in KC, this task is sufficiently sensitive to gauge the integrity of representations that may appear relatively preserved with respect to some tests, but clearly degraded on the reading test.

Semantic vs. autobiographical episodic memory

In our previous study (Westmacott et al., 2001) we report evidence of global sparing of autobiographical episodic memory in semantic dementia patient EL, and global loss of such memory in amnesic patient KC. We interpreted these findings as evidence for the continued involvement of the hippocampal complex in the representation and retrieval of autobiographical episodes, regardless of memory recency. In the present study, however, we report findings of reverse temporally graded semantic losses in these two patients and argue that, unlike personal episodes, semantic knowledge is temporarily dependent upon the hippocampal complex, becoming independent of these structures after consolidation is complete. Thus, one possible interpretation of our results is that in the initial stages of acquisition, all memories are equally dependent upon a medial temporal lobe mechanism that forms rapid, complex associations among incoming pieces of incoming stimuli to construct a coherent memory trace. However, once this initial process of cohesion, or short-term consolidation (Nadel & Moscovitch, 1997) is complete, the mechanisms underlying semantic and autobiographical episodic memory become distinct. Semantic information (including personal facts acquired through autobiographical experiences) begins a gradual process of long-term consolidation, becoming tightly integrated into existing knowledge structures in the neocortex and less hippocampally dependent[4] (see McClelland et al., 1995, and Alvarez & Squire, 1994, for network models of consolidation). Conversely, autobiographical episodic memories do not undergo this process of long-term consolidation and remain permanently dependent upon the hippocampal complex. An alternative interpretation is that the semantic system can acquire its corresponding memories in parallel with the episodic system from the very beginning. The episodic system, with the hippocampus at its core, supports and contributes to semantic memory during initial acquisition and shortly thereafter, thereby facilitating the process greatly, but not being absolutely essential to it (see Nadel & Moscovitch, 1997, for a full description of this alternative view).

These findings raise questions about the fundamental differences between semantic and episodic memory and why they might rely on distinct neural mechanisms. We suggest that these two types of memory differ both in terms of informational content and in terms of retrieval format, which capitalises on the differences in content. It is not the case that a given piece of information is inherently either semantic or episodic; rather, all information has the potential to be both semantic and episodic, depending on the way in which it is retrieved. If the information retained the temporal-spatial context in

[4] We suggest that the term "integration" may be more appropriate than long-term consolidation (see Squire, Cohen, & Nadel, 1984, for a similar view).

which it was learned or experienced, then it is episodic; however, if the information is retrieved as an isolated unit from long-term memory, and in the absence of experiential context, then it is semantic (see Tulving, 1983, 1989). These definitions imply that, in general, autobiographical episodic recall is likely to be more complex, multi-modal (visual, auditory, tactile, spatial, temporal), and emotionally charged relative to semantic recall, and is also more likely to involve a greater number of diverse brain regions distributed throughout the neocortex. Because of these qualities and characteristics, autobiographical episodic memories will always depend on the hippocampal complex to assemble, reconstruct, and bind together the many diverse elements during retrieval of an autobiographical experience. Similarly, those pieces of information that are personally-relevant—namely, personalised semantics—may remain partially hippocampally dependent and retain a distinctly episodic flavour (Westmacott et al., 2001). In contrast, once semantic memories have been consolidated, neocortical interconnections are sufficient for their reconstruction and retrieval and the hippocampal complex is no longer needed.

Conclusions

In a previous study (Westmacott et al., 2001), we showed sparing of autobiographical episodic memory across the lifetime in the semantic dementia patient, EL, and virtually complete loss of such memory in the amnesic patient, KC. The goal of the present study was to see if semantic memory loss would follow a similar pattern or if it would be temporally graded. We found patterns of temporally graded semantic memory loss in MTL amnesia and semantic dementia that are consistent with previous reports (e.g., K.S. Graham & Hodges, 1997; Graham et al., 1999; Warrington, 1996).

EL, a semantic dementia patient, showed relative sparing of semantic knowledge only for the most recent time period. In contrast, KC, an amnesic patient, showed the opposite pattern, namely, sparing of remote but not very recent premorbid semantic memories. Reading speed and accuracy proved to be sensitive measures of semantic memory and provided information about existing representations, even when other means of testing this knowledge were unavailable. Combined with findings from our previous study (Westmacott et al., 2001), these results indicate that, unlike autobiographical memories, which remain dependent on the hippocampal complex for as long as they exist, semantic memories are mediated primarily by the neocortex and can survive extensive hippocampal complex damage once the consolidation process is complete.

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