ABSTRACT

A number of investigations in semantic dementia have documented better retrieval of recent personal events compared to those in the more distant past (Graham and Hodges, 1997). Westmacott et al. (2001) challenged this result, however, finding relative preservation of remote memories in a single case of semantic dementia when he was tested using family photographs. In Experiment 1, we tested two possible explanations for the discrepancy between the published papers: (a) that there is a significant effect of modality in autobiographical retrieval in semantic dementia (e.g., patients will show better, or even preserved, remote memory when tested on nonverbal, compared to verbal, tasks); and (b) that the distinct pattern seen between patients is attributable to the different methods adopted for scoring the episodic quality of the memories. A patient with semantic dementia, AM, produced autobiographical memories to both words and family photographs. These personal events were scored by two raters using the scoring method described by Westmacott et al. (2001) and that reported by Graham and Hodges (1997). It was found that AM showed similar levels of remote memory impairment regardless of whether the cue was verbal or nonverbal. In addition, significant effects of time were revealed in AM’s performance on the verbal memory test, regardless of which method was used to score the memories. In Experiment 2, we investigated a related question: whether the relatively better retrieval of memories in semantic dementia could be due to over rehearsal of highly salient recent experiences? Four patients were tested on their ability to remember a recent event (either a trip to London or events from a Formula One Grand Prix race) using specially designed autobiographical questionnaires. It was found that all four were able to perform this task, although one patient showed evidence of some forgetting over three months, and another exhibited difficulty discriminating between two similar events. Together, the two experiments further confirm that patients with semantic dementia show a modality independent autobiographical memory deficit, with better retrieval of recent events.

Keywords: episodic memory, retrograde amnesia, semantic memory, temporal gradients, modality-specific effects

INTRODUCTION

Semantic dementia, also termed the temporal variant of frontotemporal dementia, is a neurodegenerative condition affecting predominantly the anterolateral region of the temporal lobe, with relatively less atrophy to medial temporal lobe structures (Chan et al., 2001; Galton et al., 2001). The predominant cognitive feature in semantic dementia is a progressive deterioration of conceptual knowledge about people, objects, facts and the meaning of words.
Typically, performance is poor on neuropsychological tests dependent upon semantic memory, such as picture naming, category fluency (i.e., generating as many exemplars from a semantic category as possible in a minute), word-picture matching, defining concepts in response to their names or pictures and sorting pictures or words according to pre-specified criteria (e.g., electrical versus non-electrical). Studies have also revealed that the deficit is not specific to tests requiring production or comprehension of language – patients are unable to select the correct colour for a black-and-white line drawing (e.g., yellow for a banana), draw animals or objects from memory, and point to the correct picture after hearing a sound (Bozeat et al., 2000, in press). By contrast, patients show little impairment, even at relatively late stages of the disease, on tests of phonological and syntactic processing, visuospatial ability and working memory (Hodges et al., 1995; Snowden et al., 1996b).

Turning to episodic memory, a number of studies have demonstrated preservation of day-to-day memory in semantic dementia, with significantly better retrieval of recent compared to remote personal events. For example, Snowden et al. (1996a), Graham and Hodges (1997) and Nestor et al. (2002) reported that patients with semantic dementia showed better recall of recent memories compared to those from childhood and early adulthood on the Autobiographical Memory Interview (Kopelman et al., 1990). In a single case-study, described by Graham and Hodges, a patient AM, showed clear evidence of a ‘step-like’ pattern of performance, with good recall of memories from only the last five years of his life, when asked to retrieve memories from cue words (see also JH reported in Nestor et al., 2002).

A more recent article, however, failed to find this profile in a single case of semantic dementia, EL (Westmacott et al., 2001). Westmacott and colleagues presented EL with 50 photographs evenly distributed across his lifetime, and asked him to produce detailed descriptions about the events portrayed in the photographs. He performed close to ceiling on this task and there was no evidence of an influence of event age. By contrast, EL did show an effect of time when he was asked to name the people shown in the photographs, with better naming in the recent photographs compared to people depicted in photographs documenting more remote events. This finding in the remote semantic component of the photographs test is consistent with other experiments in semantic dementia, in which effects of time (recent > remote) have been demonstrated on tests such as knowledge of famous people and public events (Graham et al., 1998; Hodges and Graham, 1998; Westmacott and Moscovitch, 2002).

Although the finding of good autobiographical memory in EL has to be interpreted with caution as his performance was not contrasted with that of matched control subjects, Westmacott et al.’s (2001) result raises the possibility that the poor remote autobiographical memory documented in other studies may be attributable to the ‘verbal’ nature of the memory tasks typically adopted in these experiments. This issue – whether patients do show consistent effects of time on both verbal and non-verbal tasks – is of significant theoretical interest.
Graham and colleagues’ (Graham and Hodges, 1997; Nestor et al., 2002) suggest that the effect of time seen in autobiographical memory in semantic dementia is support for the standard model of memory consolidation, in which the hippocampus plays a temporary role in memory acquisition and storage, with temporal neocortical regions being the permanent repository for more remote episodes (see also Alvarez and Squire, 1994; McClelland et al., 1995; Murre et al., 2001; Squire, 1992). In this model, the hippocampal complex acts as an index finger together neocortical sensorimotor information that has been activated by a recent experience. Over time, repeated reinstatement of the memory representation results in the formation of permanent links between the activated regions within the neocortex, and eventually, the retrieval of the event becomes independent of the hippocampal complex. This model provides an explanation for the pattern seen in semantic dementia: progressive damage to the temporal neocortex results in a loss of long-term memories, both semantic and autobiographical, but sparing of medial temporal lobe structures, typically asymmetrically and at early stages in the disease (Galton et al., 2001), supports the encoding of new, and relatively short-lived, recent experiences (see Nestor et al., 2002, for more details).

More recently, however, this model of memory consolidation has been challenged and it has been suggested that the hippocampus is necessary for the retrieval of all autobiographical memories regardless of the age of the memory (Moscovitch and Nadel, 1998; 1999; Nadel and Moscovitch, 1997). In this view, termed the multiple trace model, repeated reinstatement of hippocampal-neocortical ensembles results in the formation of multiple traces of the memory within the hippocampal complex, as opposed to a more permanent, and increasingly hippocampally-independent, representation within the neocortex. Consequently, medial temporal units are necessary for retrieving the memory representation for as long as it exists. The multiplicity of the traces means that older memories have more traces and are more widely distributed over the hippocampal complex than recent experiences. These two factors make older representations less vulnerable to medial temporal lobe damage and provide an explanation for why hippocampal damage sometimes results in a temporal gradient (recent < remote) in autobiographical memory (Nadel and Moscovitch, 1997).

In terms of semantic dementia, this view predicts that there should be little effect of time on tasks tapping autobiographical memory - damage to the temporal neocortex should affect all memories equally - although it is highly plausible that patients may show an autobiographical memory deficit (see Graham, 1999; Nestor et al., 2002; Westmacott et al., 2001, for more details). The data from patient EL, reported by Westmacott et al., is consistent with this alternative model of memory consolidation as the patient showed no evidence of better retrieval of memories from any one particular time period.

Given the controversial nature of autobiographical memory loss in semantic dementia, and the theoretical importance of determining why patients show a temporal effect, further studies of autobiographical memory in patients with the disease are clearly necessary, in particular those that attempt to address why there are reported differences in the degree of remote autobiographical memory impairment seen across patients.
EXPERIMENT 1

There were two major differences between Westmacott et al.’s (2001) study and the other investigations of autobiographical memory in semantic dementia: (1) EL was tested on family photographs, while all the other patients were given words as cues; and (2) Westmacott et al. designed and utilised a new scoring method which may have been less stringent than that used by other researchers. At present, therefore, it is not clear whether the relatively good remote autobiographical memory found in Westmacott et al.’s case reflects the scoring method, or perhaps better access to personal events from the past when non-verbal, personally relevant, cues are provided. The aim of the following experiment, therefore, was to test whether either or both of these two factors could account for the discrepancy in the literature by comparing the ability of AM (previously reported in Graham and Hodges, 1997) to retrieve autobiographical memories from words and family photographs. In addition, we scored AM’s memories using both of the scoring methods that have been described in the literature. This allowed us to contrast the two systems and to see if the pattern reported for AM by Graham and Hodges (1997) would be evident across methodological approaches, and when different subjects rated the memories.

SUBJECT

A single patient with semantic dementia, AM, took part in this experiment. A detailed case history of AM has previously been reported in Graham and Hodges (1997) and Murre et al. (2001), so we will only briefly summarise his neuropsychological profile here. AM was aged 65 years at time of testing. He had left school at 16, but obtained an undergraduate and Masters degree at university through night school. When he first presented to the Memory Clinic at Addenbrooke’s Hospital, Cambridge in 1994, he was a works manager with responsibility for over 450 people. He presented with a five-year history of word finding and comprehension difficulties, and formal neuropsychological testing at this time confirmed that AM was both anomic (he was able to name correctly only 3 out 48 black and white line drawings of familiar objects) and moderately impaired on tests of single-word comprehension, such as word-picture matching from the Hodges semantic battery (36/48; controls 47.4, s.d. = 1.1). By contrast, his copy of the Rey Complex Figure (Osterrieth, 1944) was perfect and he was within the normal range on non-verbal tests of problem solving (e.g. Raven’s Coloured Progressive Matrices, 1962). On some tests of episodic memory, AM showed a good level of performance: when asked to reproduce the Rey Complex Figure after a 45-minute delay he scored close to the control average (AM = 12.5; age matched controls = 15.2 ± 7.4).

Longitudinal testing in AM revealed a rapid decline on tests of single-word comprehension (in October 1995, he scored 13/48 on the aforementioned word-picture matching test), although performance on visuo-perceptual and non-verbal problem solving tests remained stable (see Table I, Experiment 2). While his episodic memory, such as delayed copy of the Rey Figure (Osterrieth, 1944), also declined over this time-period, he was still able to reproduce some aspects
of the figure between 1994 and 1996 (see Figure 1c, Murre et al., 2001). Neuroimaging (see the bottom MRI scan in Figure 1; Graham and Hodges, 1997) documented marked bilateral infero-lateral temporal lobe atrophy, although this was greater on the left.

**MATERIALS AND METHODS**

AM was tested on two tests of autobiographical memory.

**(A) Verbal Autobiographical Memory Test (Crovitz task)**

This test, based on the Galton-Crovitz method for tapping autobiographical memory (Crovitz and Schiffman, 1974), was initially reported in Graham and Hodges (1997). In the original task, AM was given 15 words (for example, holiday, journey, death, friend, birthday etc.) and asked to produce a detailed and specific autobiographical memory in response to each word. The 15 words were given four times in order to elicit memories from four different time-periods corresponding to AM’s age: 0-18, 19-39, 40-59 and 60-65. For example, the experimenter would say to AM, “Could you tell me about something that happened related to the word party during the period from when you were born to 18 years old?”. The four time-periods were selected on the basis of two criteria (see Graham and Hodges, 1997, for further details): (a) to test autobiographical memory for the whole of AM’s life; and (b) to determine whether he would show better memory for a very recent time-period (five years) compared to the rest of his life (three twenty-year time-periods). The order of presentation (both for time period and item) was randomised, and in order to encourage AM to produce as much detail as possible, there was no time limit and he was prompted if necessary, for example, “Can you tell me more about that?”; “Can you be more specific?”.

For the purposes of the analyses here, we used the original transcripts collected and reported by Graham and Hodges (1997), both for AM and control subjects, with one small modification. AM had been consistently confused by two of the target words (for example, he muddled ‘birthday’ with ‘wedding’) when initially tested, so we removed these two confounding items in the following analysis. There was no evidence that he misunderstood or failed to understand any of the other cue-words. In total, therefore, we present data here for 13 out of the 15 original items described in Graham and Hodges (a total of 52 memories produced by AM, and each of his matched control subjects, over the four time-periods).

The control subjects were three age-, education- and sex-matched participants from the MRC Cognition and Brain Sciences Volunteer Panel. At time of testing, all subjects were the same age as AM (65 years old) and like the patient, were university graduates who had been highly successful in their chosen profession. Further details about these subjects can be obtained from Graham and Hodges (1997), and it should be noted that the data reported for the controls is based on the scoring system described by these authors (see (A) under Scoring below).
The second autobiographical memory task given to AM was based on a set of 24 family photographs – this data has not been previously reported (unlike the Crovitz task above), although it was collected at the same time as the Crovitz task (between 1995-1996). Prior to testing AM, we asked his wife to look through their photograph album and provide a set of photographs which corresponded to significant events from their past. For example, she selected a photograph of AM’s wedding day; a picture depicting his three children in the garden on the day that their daughter had climbed a ladder onto the roof of the house; and a photograph of AM being presented with gifts from his work colleagues prior to him moving abroad. The majority of these photographs contained pictures of people and were sufficiently detailed that AM’s wife was able to provide information about the people in the photograph, the events which lead up to the photograph and the date when the photograph had been taken. In terms of memory age, the photographs spanned the whole of AM’s life, starting in early adulthood (i.e., a photograph of AM playing football) and ending with events from his more recent life (i.e., a photograph of AM with two friends who had visited from Canada). Notably, however, the majority of the stimuli covered the period of time in which AM showed a significant deficit (approximately the first 60 years of his life) in the Graham and Hodges (1997) study, so for the purposes of this experiment, all the photographs were considered to belong to this ‘remote’ time-period, rather than tapping more recent autobiographical experiences.

To test AM’s autobiographical memory, he was presented with all 24 photographs one after each other (in a randomised order) and asked to produce information about the people shown and to describe an event he could remember related to the photograph. In order to maximise AM’s performance, there was no time limit and he was prompted using similar cues to those described previously for the verbal memory task.

SCORING

Two scoring methods were adopted and both the verbal and nonverbal autobiographical memories scored by two raters (AK and WPG) using these schemes.

(A) Graham and Hodges (1997; GH method)

This method uses a 0-5 point scale (see Figure 1), and is thought to measure episodic specificity and detail. The most important distinction in this scheme is that raters score memories based on whether they are generic (e.g., repeated episodes, such as walking to work, eating breakfast etc.) or specific (e.g., an event which could only have occurred once, such as falling out of a tree as a child).

(B) Westmacott et al. (2001; W method)

In this scheme, memories are scored for the presence of seven criteria (see Westmacott et al. for more details): (1) recognition (e.g., evidence of familiarity)
of the people depicted in the photograph (e.g., ‘I know him’); (2) identification (e.g., naming) of the people in the photograph; (3) expression of emotion (e.g., smiling, laughing, emotional tone, verbal description of emotion); (4) sense of event recognition or familiarity (e.g., presence of statements such as, ‘I remember...’ and ‘I know...’); (5) knowledge of spatial/situational context (e.g., location, country, ongoing event or activity); (6) knowledge of temporal context (e.g., year, season, own age at time of event); and (7) narrative structure (e.g., describing the sequence of events or how the event relates to other life experiences). It was possible to score both the verbal and nonverbal memory tasks using virtually all the seven criteria, although it should be noted that criterion (1) – recognition of people – was not possible in the Crovitz task.

The first two criteria – recognition and identification of people – are considered separate from the other five criteria, which together constitute a measure of episodic quality (out of a score of five). In total, therefore, the raters provided a score for (a) recognition of people (only from photographs); (b) identification of people; and (c) an episodic measure (out of five).

**RESULTS**

Figures 2 and 3 show the performance of AM on the verbal (Crovitz) and nonverbal (family photographs) autobiographical memory tests, respectively (maximum score, for both scoring systems, was 65 per time-period in the Crovitz and 120 for photographs). In terms of the Crovitz task, Friedman analyses revealed a significant effect of time in AM’s performance regardless of how the memories were scored (GH: $\chi^2 = 16.1$, p < .001; W: $\chi^2 = 14.0$, p < .001). Wilcoxon rank sum analyses further confirmed that the effect of time was due to better performance in the most recent time period compared to the
three other time life periods tested (GH: 0-18: Z = 2.2, p < .05; 19-39: Z = 3.1, p < .005; 40-59: Z = 2.6, p < .01; W: 0-18: Z = 2.9, p < .01; 19-39: Z = 2.7, p < .01; 40-59: Z = 2.7, p < .01). No other comparisons reached statistical significance revealing that there was no difference in scores between the three most distant time-periods. Although Figure 2 reveals a small numerical advantage for Westmacott et al.’s (2001) scoring method compared to that adopted by Graham and Hodges (1997), this difference was not significant when tested using a Wilcoxon rank sum analysis (Z = 1.0, p = .32).

Of note is the fact that the performance of the two new raters on the Crovitz task, using the GH methodology, was identical to that seen with the original raters, taking into account the reduction of the data-set from 15 to 13 items (Original GH: χ² = 17.4, p < .001). As a result, a comparison between the original data-set and the scores obtained using Westmacott et al.’s (2001)
scoring method also failed to reveal a significant difference ($Z = 1.5$, $p = .12$).

Figure 3 documents the results from the nonverbal autobiographical memory task. On the GH scoring method, AM gained an overall score of 50/120 (0.42). A similar, albeit slightly higher score, was obtained when the memories were scored using the method described by Westmacott and colleagues: 63/120 (.53). A comparison of the two scoring systems based on a Wilcoxon Rank Sum analysis revealed that there was a significant difference ($Z = 2.8$, $p < .005$), with the W scoring system resulting in consistently higher scores than the GH system. Westmacott et al.’s scheme provided two other scoring values, other than episodic quality: (a) recognition and (b) naming of people. AM scored quite highly on the recognition component (19.5/24), suggesting he was familiar to some degree with the people represented in the photographs, but was rarely able to produce the names of the people depicted (9.5/24).
The aim of this first experiment was to investigate whether either the scoring system or the method of testing (nonverbal versus verbal) was a significant factor in explaining why Westmacott et al.’s (2001) patient with semantic dementia showed preserved remote autobiographical memory; a pattern which has not been seen in other cases. In order to address this issue, we studied verbal and nonverbal autobiographical memory in a patient (AM) with semantic dementia, who had previously been shown to exhibit an impairment to remote autobiographical memory.

The study revealed that AM showed a similar, and significant, effect of time on the Crovitz test – with better retrieval of recent memories compared to those from the more distant past – regardless of whether his memories were scored using the method described by Westmacott and colleagues (2001) or that used by Graham and Hodges (1997). Although it was not possible to investigate time specifically in the family photographs test, again both scoring methods revealed impairment in AM’s ability to recall remote autobiographical memories when he was tested nonverbally.

The degree of impairment in remote autobiographical memory shown by AM, based on proportions, was relatively equivalent across both the Crovitz and family photographs test, with AM averaging approximately 42% of the total available. This finding is evidence that AM’s autobiographical memory deficit is relatively consistent across modality and that unlike the patient described by Westmacott et al. he does not show better retrieval of personal events from family photographs.

One further issue which was addressed in this experiment was whether the two scoring systems were equally stringent: one possible explanation for the contradictory findings in the literature is that the method adopted by Westmacott et al. (2001) was less strict than that used by Graham and Hodges (1997). Experiment 1 revealed, for both verbal and nonverbal tasks, that AM was more likely to be given higher scores by our two raters when they were using the W method compared to the GH method, although importantly this difference was only statistically significant in the family photographs task and the overall increase in AM’s score was small.

In summary, Experiment 1 demonstrates that it is unlikely that modality differences – better access and retrieval of autobiographical memories from nonverbal (photographs) compared with verbal (words) cues – can explain the discrepancies between the published studies of autobiographical memory in semantic dementia. Although Westmacott et al.’s (2001) patient may well have demonstrated such a modality effect – the authors did not test EL on a verbal task – it is clear that AM showed no such pattern. This finding is important as it implies that the ‘step-like’ pattern documented in AM (see also JH, Nestor et al., 2002) reflects a ‘loss’ of autobiographical memories rather than a modality-specific retrieval deficit, a result which is difficult to reconcile easily with the multiple trace model (Nadel and Moscovitch, 1997; although see Nestor et al., 2002). Second, the experiment revealed that the two scoring systems used in the literature are both sensitive enough to detect significant effects of time in
Autobiographical recall. Notably, however, on both autobiographical memory tests, the memories received consistently higher scores when the Westmacott et al. method was used compared to that described by Graham and Hodges (1997). It is still possible, therefore, that the disparity in the literature – between AM and EL – could reflect the different scoring systems, although there was little evidence to support this hypothesis in patient AM.

**EXPERIMENT 2**

In this second experiment, we were interested in addressing more specifically the issue of whether recent autobiographical memories are truly preserved in semantic dementia. In Experiment 1, AM showed exceptionally good performance in the most recent time-period (60-65) suggesting that his recent episodic memory was relatively normal (see Figure 2). To date, however, patients with semantic dementia have been tested almost exclusively on standard tests of autobiographical memory, such as the Autobiographical Memory Interview (Kopelman et al., 1990; Snowden et al., 1996a) and the Crovitz task (Graham and Hodges, 1997). It is possible, therefore, that the better retrieval of recent memories in semantic dementia is artefactual and reflects our methods of testing autobiographical memory. More specifically, the Crovitz task is actually extremely easy, at least in terms of memory selection, because the cue words are relatively unconstrained (e.g., *party* could refer to any social gathering; *holiday* to any journey or trip) and the time windows adopted are often relatively big (e.g., five years). Even the family photographs experiment described by Westmacott et al. (2001), and used in Experiment 1, in which specific episodes from the past are tapped, is not particularly strict because we can never be sure that the event the patient produces is definitely related to the photograph and we are often left scoring memories on the basis of their plausibility, rather than their accuracy.

There is a possibility, therefore, that patients with semantic dementia are actually recalling key, and highly salient, events which they have been repeatedly rehearsing, a pattern which is likely to benefit recent experiences much more than older ones, causing us to assume that recent autobiographical retrieval is relatively normal. For example, Schwartz and Chawluk (1990) describe a case (Susan G.) with progressive language difficulties, who kept a notebook diary in which she recorded significant events from each day. Susan showed a remarkable ability to recount events and episodes from the past due to her frequent rehearsal of these autobiographical narratives, which over time became stylised and stereotyped around several events. Strikingly, Susan’s event recall was very different from the rest of her spontaneous speech, in the sense that the episodes were immune from the linguistic difficulties she showed on other tests of production and comprehension.

In this experiment, we attempted to circumvent this difficult issue by investigating the ability of patients with semantic dementia to recall real life events, and in one case public events, which had been experienced by both the patient and an experimenter. In three of the four cases described, we were able to achieve this by undertaking a trip to London with the patient and their spouse, and subsequently creating a verbal test related to events that had occurred during
the trip (e.g., whether we had taken a taxi or underground train in London; whether the spouse was in the room at the time the patient had an injection; where and when we had eaten lunch etc.).

In a fourth patient, GCB, we utilised her interest in Formula One Grand Prix: GCB used to watch these races regularly and to test her recall of these events we created a similar verbal memory test based on the events of three races. Although GCB had personal experience with the races – in the sense that she experienced the race in a particular place and at a set time – this test can be considered more akin to a remote semantic task, in which GCB had less personal involvement, and where she was asked to recall more factual-like information about the event. In addition, we tested whether the presence of a similar event between study and test would impair GCB’s memory by asking her about, (a) one race where there was no other meeting held between her watching the race and being given our memory test (non-interference condition); and (b) by testing her at a similar delay on a further Grand Prix, when another race had taken place between study and test (interference condition). Recent studies of new learning in semantic dementia have revealed good ‘perceptually-dependent’ memory (whereby patients perform well in conditions where items are identical between study and test, but poorly when stimuli are no longer known to the patients and the test item is perceptually different from that seen previously, Graham et al., 2000; Simons et al., 2001). To date, it has not been possible to test for a similar effect in autobiographical memory: in GCB’s cases, however, the presence of a similar event between the study and test session may disrupt her memory for the initial race.

Based on previous results, we predicted that our patients would be capable of retrieving details about their very recent experiences, although given the linguistically demanding nature of our memory tasks their recall may be more errorful than the control subjects (in most cases, the patient’s spouse). We also expected to see a significant impact on GCB’s memory for the Grands Prix when an similar interference event had occurred between study and test compared to the condition in which there was no meeting held between her watching the programme and completing the questionnaire.

**Subjects**

Four patients with semantic dementia took part in this experiment: AM (Graham and Hodges, 1997; Murre et al., 2001; Knott et al., 1994), GCB, JH and DG (all reported in Hodges and Graham, 1998). The patients were identified through the Memory Disorders Clinic at Addenbrooke’s Hospital, Cambridge, UK. All four presented with a history of progressive deterioration of vocabulary and comprehension and showed significant impairment on semantic tasks, such as picture naming, category fluency, word-picture matching and the Pyramid and Palmtrees Test (Howard and Patterson, 1992) of associative semantic knowledge (see Table I). On the Rey Complex Figure (Osterrieth, 1944), copying was generally good (except for DG). After a delay, all patients recalled some information about the figure, although performance was quite variable. In terms of other cognitive domains, performance on forwards and backwards digit span (see Table I), tests of phonological and syntactic processing, and visual-spatial tasks was good.
TABLE I

<table>
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<th>TESTS</th>
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<th>JH</th>
<th>AM</th>
<th>Controls</th>
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</tbody>
</table>

Performance of each patient with semantic dementia, and 24 healthy control participants, on a battery of standard neuropsychological tests. The patients are ordered by MMSE – Mini-Mental State Examination (Folstein et al., 1975) score. Maximum scores are in parentheses after the test name and the control data (mean and standard deviation) are from Hodges and Patterson (1995). Abbreviations and references: Rey Figure (Osterrieth, 1944); RMT – Recognition Memory Test (Warrington, 1984); WPM – Word-Picture Matching (Hodges and Patterson, 1995); and PPT – Pyramid and Palm Trees Test (Howard and Patterson, 1982). Chance performance for the RMT and PPT are 0.50. For WPM, chance is between 0.10 and 0.13.

MATERIALS AND METHODS

(A) Trip to London

Two of the patients – AM and DG – were accompanied by an experimenter (KG) on a day trip to London from Cambridge. JH – who also undertook a trip to London – was accompanied by her spouse as they went directly from their home. In London, all three patients took part in an imaging experiment designed to investigate semantic function in semantic dementia and underwent two scans, a structural MRI and a functional PET (see Mummery et al., 1999 for details about this experiment). To test the ability of the patients to recall events from their trip, a 24-item autobiographical memory questionnaire was created as soon after the trip as possible. In the case of AM and DG, this test was constructed on the night of the trip by the experimenter who had accompanied them to London. For JH, however, the test was produced in collaboration with her spouse who FAXed a detailed description of the day in London to the experimenter later in the week. In all patients, the test comprised sentences describing 12 real and 12 made-up, but plausible, events (see Table IIa for examples from AM’s questionnaire).

To test the patient’s memory of the events that had occurred during the day, the experimenter read out the questions to the patient and asked them to respond yes or no if they thought the event had or had not happened, respectively. If the patient failed to comprehend any of the language (e.g., ticket inspector), the experimenter explained in more details exactly what this term meant, without providing any further information which would help identify the correct response.
to the question. The questions were presented to the patient in the same order that the events had occurred during the day, predominantly to aid comprehension of the test questions. Until receiving the memory test, neither the patient nor their control subject was aware that they would be tested on their memory of trip.

(B) Formula One Grands Prix

In another patient with semantic dementia – in whom it was not possible to test her recall of the trip to London – we investigated her ability to remember details about a television programme. GCB was particularly fond of the Formula One Grands Prix and would watch the events on television all the way through, a habit that meant it was possible to test her memory of the races. In this case, the experimenter (KG) also watched the event (on a separate occasion) and created a 24-item questionnaire based on what had happened during the race (see Table IIb for examples from GCB’s questionnaire). As for the other patients, these questions required a yes or no response (with 12 questions from each category) and the questions were in the same order that the events occurred. GCB was not explicitly told prior to watching the races that she would be tested on them, and there was no evidence after the first testing session (for the Australian Grand Prix) that she rehearsed or attempted to remember more about the events occurring in subsequent races.

Testing Sessions

AM was tested on his questionnaire on three separate occasions: (a) the day after the event, (b) one month and (c) three months later. Unfortunately, DG lived too far away to be tested repeatedly, so she was only tested the day after

TABLE II
(a) Examples from AM’s autobiographical questionnaire based on events that occurred during his trip to London to take part in a functional neuroimaging experiment; and (b) Examples from GCB’s autobiographical questionnaire based on events from the Australian Grand Prix (March 1996). Y = yes; N = no.

<table>
<thead>
<tr>
<th>(a) AM’s trip to London</th>
<th>Y = yes; N = no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did Raymond come and get you from the ward?</td>
<td>N</td>
</tr>
<tr>
<td>Did we sit on the wrong train at first?</td>
<td>Y</td>
</tr>
<tr>
<td>Did the train stop on the way to London?</td>
<td>N</td>
</tr>
<tr>
<td>Did you and I go to toilet just after lunch?</td>
<td>Y</td>
</tr>
<tr>
<td>Did your wife go away for a cup of coffee before your scan?</td>
<td>Y</td>
</tr>
<tr>
<td>Did you meet a tall man called Richard during the scan?</td>
<td>Y</td>
</tr>
<tr>
<td>Was the taxi waiting outside the hospital when we left?</td>
<td>N</td>
</tr>
<tr>
<td>Did we sit together on the train back to Cambridge?</td>
<td>N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(b) Australian Grand Prix</th>
<th>Y = yes; N = no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was it raining on the day of the race?</td>
<td>N</td>
</tr>
<tr>
<td>Was it the first time that the race had been held in Melbourne?</td>
<td>Y</td>
</tr>
<tr>
<td>Was the total number of laps 65?</td>
<td>N</td>
</tr>
<tr>
<td>Was Michael Schumacher first on the starting grid?</td>
<td>Y</td>
</tr>
<tr>
<td>Was there a crash on the first lap?</td>
<td>Y</td>
</tr>
<tr>
<td>Did Brundle’s car split in two?</td>
<td>Y</td>
</tr>
<tr>
<td>Did Damon Hill make the first fuel stop?</td>
<td>N</td>
</tr>
<tr>
<td>Did Damon Hill’s car become covered in oil?</td>
<td>Y</td>
</tr>
</tbody>
</table>
the trip to London. JH was tested at one month and three months after the event. AM’s and JH’s spouses were given the identical questionnaire as their partner at the same times as the patient; it was not, unfortunately, possible to obtain data from DG’s spouse because only the experimenter (KG) accompanied DG to London.

In total, GCB was tested on her memory of three races that occurred in sequence (the Australian, Brazilian and Argentinian meetings in 1996). For the Australian Grand Prix, the first race, she was tested 21 days after the meeting had occurred (and there were no other races held between her initial exposure to the race and the test session). This questionnaire was intended to measure how well GCB could recall the events of the race after a significant (three-week) delay when there had been no other interfering event. The next Grand Prix, the Brazilian, was held two days after GCB was tested on the Australian event, and she was tested on her knowledge of this race after a similar delay to that used for the Australian race (19 days). Unlike the Australian race, however, another Grand Prix (the Argentinian) had occurred in between GCB watching the Brazilian meeting and being tested on her knowledge of this race. Her performance on the Brazilian race questionnaire, therefore, was intended as a contrast with the Australian meeting, but where a similar event (the Argentinian race) had occurred in between and might have interfered with her performance. In the second testing session, therefore, GCB was tested on her knowledge of both the Argentinian and Brazilian races, with the delays between when the meetings were held and GCB’s testing being 12 and 19 days, respectively.

For GCB’s experiment, a control subject – a 23 year old Ph.D. student – who was also interested in Formula One Grand Prix was tested on the Australian Grand Prix, but not the other two races (Brazilian and Argentinian).

**SCORING**

A total score of 24 was possible for each questionnaire. For the purposes of comparison between patient and control (in some cases, the questions could not be answered by the spouse because they were not present during the event), proportions are presented in the results section. It should also be noted that on some occasions, the patient failed to answer yes or no to a question; for example, to the following question about the Australian Grand Prix, “Was the total number of laps 65?”, GCB provided the correct number of laps, responding “It was 57 I think”, rather than answering ‘no’ to the question. As she had produced information which indicated that she did not think the answer was 65, and would not respond yes or no with prompting, she was scored correct on this question. Given the highly verbal nature of the task – and the complicated language involved (see Table II) – it was considered appropriate to score the patient correct or incorrect even if they did not directly respond yes or no to the question, as long as they provided information which indicated that they either agreed or disagreed with the statement. In general, however, this was a rare occurrence and the experimenter attempted to obtain a definitive response.
RESULTS

Trip to London

A day after the trip to London, both AM and DG showed good recall of events from the trip, scoring 0.88 and 0.79, respectively (see Table III for a summary). AM’s wife correctly answered all 22 questions that were relevant to her, suggesting that neurologically normal subjects would have little problem with the autobiographical questionnaire and that the patients’ recall was impaired. One month later, AM was retested. At this time, he showed a drop in his performance on the test achieving a proportional score of 0.83. His wife again was able to correctly answer all 22 of the questions relevant to her. By three months, AM’s ability to retrieve the details of the event was significantly worse (0.71), although notably his performance was well above chance. At this time his wife was still able to answer all the questions correctly and showed no evidence of forgetting.

JH was also tested at one month and three months after her trip to London. On both occasions she obtained a proportional score of 0.75. Her husband was able to answer more of the questions correctly and achieved a score of 0.92 at one month and three months after the event. In summary, all three patients showed poorer performance on the autobiographical test than their matched control subjects, but notably their ability to recall details was still quite good. And while there was no evidence that the controls forgot details about the event over a delay of three months, to the extent that they could still answer questions correctly, AM did show some forgetting over time.

Formula One Grands Prix

GCB was initially tested on the Australian Grand Prix – the first event in the series – three weeks after it occurred. On the 24-item questionnaire she showed good recall on this difficult memory task, scoring 0.83. The control subject, a Ph.D. student, obtained a better score, responding correctly to virtually all the questions (0.95). Twenty one days later, GCB was tested on two races, the Brazilian and the Argentinian, both of which had occurred since the Australian race. GCB showed notably poor recall on both these questionnaires, achieving a

<table>
<thead>
<tr>
<th>Subject</th>
<th>1 day</th>
<th>1 month</th>
<th>3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>0.88</td>
<td>0.83</td>
<td>0.71</td>
</tr>
<tr>
<td>AM’s wife</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>DG</td>
<td>0.79</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>JH</td>
<td>NT</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>JH’s husband</td>
<td>NT</td>
<td>0.92</td>
<td>0.92</td>
</tr>
</tbody>
</table>
score of 0.71 for questions relating to the Argentinian race (which had taken place 12 days previously) and 0.54 (chance performance) to events from the Brazilian race (which had taken place 19 days earlier). GCB scored poorly on the Brazilian race because she was confused about whether the events she was questioned about had occurred in the Brazilian or Argentinian race, typically responding to the Brazilian questions with responses based on what she remembered from the Argentinian event. This confusion was strongly evident because the experimenter had also watched all three races and yet had no problem discriminating between events from each race.

**DISCUSSION**

The results from Experiment 2 reveal a number of interesting insights about recent autobiographical memory in semantic dementia. First, it is clear that patients with semantic dementia can remember details about very recent experiences: all four of the cases described here achieved a reasonable score on our task, which was notably highly verbally-demanding and included many low frequency words and names, especially in GCB’s case (e.g., injection; car park; ward; fuel stop; spin; Damon Hill etc.). It is important to note, however, that none of the patients showed equivalent performance to the control subjects, which in two cases were spouses who had also experienced the same events. It is not clear from our study, therefore, whether the patients’ mild deficits represent a true autobiographical memory impairment – e.g., poorer episodic memory than normal subjects – or the patients’ lack of comprehension of some of the vocabulary in the questionnaires.

The second important finding from the experiment relates to AM’s decline over the three months in his ability to retrieve events, with his initial score of 21/24 (0.88) dropping to 17/24 (0.71). Although this drop is not dramatic, and certainly he was not scoring at chance after three months, his wife (and JH’s spouse) showed no evidence of such forgetting obtaining a similar score three months after the event compared to when they were tested one day and one month after the episode. This result indicates that AM might have particular difficulties holding onto events he has recently experienced, and that they might be forgotten more rapidly over time. It is notable, however, that JH did not decline like AM during this time period, a discrepancy that is probably related to disease severity (AM was very cognitively impaired at time of testing, see Table I).

The third result of note from Experiment 2 relates to GCB’s performance on the Grand Prix questionnaires. Initially, she showed remarkably good performance on this rather difficult memory task: for the Australian Grand Prix she responded correctly to 21/24 of the questions three weeks after the event (the control subject, who was not age-matched, scored 23/24). This result suggests that GCB was able to encode and retrieve details of recent events, even those she had experienced via the television. When she was tested on two other Grands Prix, however, she showed extremely poor performance. In particular, she was unable to answer questions about the Brazilian Grand Prix – which had occurred approximately three weeks earlier – because she was muddled between
events from this race and the more recent one based in Argentina. This confusion seems akin to a source memory deficit: GCB was not able to remember in which race a particular event occurred and the most recent race seemed to take precedence over the more remote race. Given that the time interval between GCB being tested on the Australian and Brazilian races was similar (approximately three weeks), yet she showed dramatically different levels of remembering (83% vs 54%, respectively), it seems reasonable to conclude that it was an interference effect from the most recent race (Argentinian) which affected her memory for the Brazilian Grand Prix.

In other articles (notably Murre et al., 2001; Graham et al., 1999b) we have found that patients with semantic dementia show abnormal effects of forgetting, and proposed that this may be due to poor cortical consolidation. More specifically, in normal healthy subjects, overwriting of new memories (which are presumably dependent upon the hippocampus) is typically counteracted by the gradual formation of more permanent representations within the neocortex (the process of memory consolidation). Given that the pathology in semantic dementia is greatest in neocortical regions, it is likely that there will be poor consolidation between the hippocampus and neocortex in patients with the disease and that this will result in more rapid overwriting of memories dependent upon hippocampal regions. Furthermore, the degree of overwriting will depend upon the extent of neocortical atrophy, so that those patients with the greatest loss of semantic knowledge will be most likely to show rapid forgetting (a hypothesis which may explain why AM and JH performed differently in this experiment).

There is accruing evidence that some patients with semantic dementia show abnormally rapid forgetting, especially on tests of verbal memory (e.g., recall of word lists, Graham et al., 2002) and on vocabulary for categories which are less well-known to a patient (e.g., names of stones and gems, Graham et al., 1999b). The data from AM and GCB is consistent with these other experiments: AM showed a significant loss of memory for his trip to London (a finding that was not replicated in his wife or JH’s spouse), and GCB showed a strong effect of interference on memory when a similar event, with the same participants (e.g., drivers) and identical sub-episodes (e.g., fuel stops and car crashes) occurred between study and test. Consequently, the memory representation set down by the patients seems rather ‘fragile’ and easily dislodged, although it should be noted that in none of these studies, including the one here, has it been possible to contrast forgetting in the patients directly with controls. This has been for two reasons: (a) in this study, and in Graham et al. (2002), the levels of performance of the patients and controls were not equivalent after the study phase, a factor which makes it difficult to contrast forgetting ‘slopes’; and (b) in Graham et al. (1999b), the patient showed a level of performance that was significantly better than controls due to the use of an unusual practice strategy. Consequently, the findings here should be treated with caution until further studies of ‘forgetting’ in semantic dementia have been undertaken, especially those that address the aforementioned methodological issues (see Downes et al., 1998; Issac and Mayes, 1999a, b; Mayes et al., 1994, for detailed discussion about confounds in experiments investigating forgetting rates).
In summary, the data from our real-life autobiographical memory experiment provides further support for the view that recent memory can be good, albeit not normal, in semantic dementia. In particular, it is useful to remember that patients in the early stages of Alzheimer’s disease would be unlikely to show any recall on the type of task we used in Experiment 2. So, even though our patients performed less well than their spousal controls, they still showed relative preservation of episodic recollection. These findings confirm that the better performance seen in semantic dementia on the standard tasks of autobiographical memory is likely to be real, and that inflated scores caused by the production of highly salient, repeatedly rehearsed, recent episodes is an unlikely explanation of the pattern. The experiment also illustrated, however, that the level of performance on autobiographical tasks can be affected by two other factors: (a) time between event and test (AM showed evidence of more rapid forgetting than his wife of his London trip); and (b) interference effects from similar events (GCB was unable to recall details of the Brazilian Grand Prix, despite good performance on the earlier Australian race, once she had watched the Argentinian event).

**General Discussion**

The results from our experiments are further support for the view that patients with semantic dementia show a time-dependent effect in autobiographical memory retrieval, with better recall of recent memories compared to those from the more distant past. Experiment 1 revealed that this pattern was unlikely to be due to modality of testing (verbal vs nonverbal) or scoring method, and Experiment 2 documented good memory even on tests based on real-life events, a pattern that confirms the findings from standard tasks, and argues against an explanation in terms of the production of highly salient events which are repeatedly rehearsed (see Schwartz and Chawluk, 1990, for a case in which this type of stereotyped narrative was evident). The most parsimonious explanation for this ‘step-like’ effect in autobiographical memory in semantic dementia, at least at present, is the standard model of memory consolidation, in which the neocortex is the permanent repository of older autobiographical and semantic memories, while the medial temporal lobe is necessary for the initial acquisition and retrieval of these memories (although see Nestor et al., 2002, for an explanation of this pattern in terms of the multiple trace model).

Two further questions are raised by our experiments. First, AM’s performance on the Crovitz task in Experiment 1, as measured by both scoring systems, was similar to controls in the most recent time-period suggesting completely normal retrieval of recent episodes. Yet he, and the other three patients, showed poorer performance than two controls on the questionnaire about their trips to London, implying that their recent memory was not actually normal. Our interpretation of this difference would be that the questionnaire task, despite requiring only a yes/no response, was probably one of the most difficult and demanding autobiographical tasks we could have designed for patients with semantic dementia, given the need to include low frequency and occasionally technical vocabulary. An alternative view might be that recent
memory is impaired in semantic dementia, and that this is revealed when one taps a specific event, as opposed to allowing the patient more flexibility in memory retrieval. Further study with naturalistic experiments which incorporate verbal and non-verbal testing methods should help determine whether the pattern reflects test materials, or a true autobiographical deficit. In addition, however, researchers should take into account the fact that semantic dementia is a progressive condition and that not all patients show good episodic memory (see Table I): studies of recognition memory in the disease have found that some patients have mild impairment, a result which has been interpreted – and experimentally demonstrated – as reflecting a movement of pathology into medial temporal lobe structures at later stages of the disease (Graham et al., 2000; Simons et al., 2001, 2002). Studies of autobiographical memory in semantic dementia should be considered, therefore, alongside volumetric measures of the extent of atrophy in medial temporal lobe regions.

Finally, how do we explain the discrepancy in the literature between AM (Graham and Hodges, 1997) and EL (Westmacott et al., 2001)? One possible explanation relates to the locus of pathology, in particular whether damage to the right temporal lobe is necessary for a severe autobiographical memory deficit. A recent study in patients with non-progressive temporal lobe lesions found that patients with selective left temporal lobe damage were typically poor at recalling personal semantic details but showed no evidence of an impairment on tests of autobiographical memory. By contrast, extensive autobiographical memory deficits were evident in patients with bilateral temporal lobe lesions (Eslinger, 1998). Considering AM and EL, it is interesting to note that visual rating of AM’s temporal lobes revealed marked bilateral atrophy (Simons et al., 2001), but that Westmacott et al.’s (2001) patient was reported to have relatively selective left temporal pathology. In addition, laterality may interact with modality effects: Lambon Ralph et al. (1999) found that semantic dementia patients with left temporal lobe atrophy performed better, although not normally, when asked to produce semantic facts from pictures compared to words; and that patients with predominant right temporal atrophy typically showed the opposite pattern (better performance from words).

Given these studies, it is possible that patients with semantic dementia, who have selective left temporal lobe damage, may show poor performance on verbal memory tasks but good autobiographical memory recall from nonverbal cues. By contrast, a patient like AM – who has bilateral temporal lobe atrophy – is likely to show similar patterns of autobiographical memory deficit when tested from verbal and nonverbal cues. Further studies in semantic dementia, which compare performance on verbal and nonverbal autobiographical memory tasks, and also take into account the locus of pathology, will hopefully address this complicated issue.

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