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LOST FOR WORDS OR LOSS OF MEMORIES? AUTOBIOGRAPHICAL MEMORY IN SEMANTIC DEMENTIA

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Recent reports have suggested that patients with semantic dementia show a loss of early (remote) autobiographical memories with pronounced sparing of recent memories (Graham & Hodges, 1997; Snowden, Griffiths, & Neary, 1996), i.e., a "reversed" temporal gradient or "Ribot effect". At first sight, these findings suggest that the deficits in "semantic" dementia go beyond the semantic domain, involving aspects of autobiographical (episodic) memory. It has also been proposed that there is a "step-like" function with personal memories preserved for 18 months to 2 years in the immediate past. This view is consistent with the theory that the hippocampal complex/medial temporal lobe (relatively intact in semantic dementia) plays a time-limited role in the acquisition and storage of memories, while the temporal neocortex (damaged in semantic dementia) is required for long-term storage and retrieval. In this study we ask whether (a) previous tests have underestimated the integrity of remote memory in semantic dementia as a result of not allowing for these patients' comprehension and language production difficulties, and (b) whether a recency effect, if obtained, is genuinely step-like or more graded. We used a cued autobiographical memory interview with semantic dementia patient, IH, to examine the effect of providing increasingly specific lexical cues to probe salient events throughout his lifespan. Results demonstrated that the provision of specific cues enabled IH to access and express memories from his childhood and early adulthood as well as from more recent times. There was a gentle recency effect only for intermediate levels of cueing, indicating that recent memories were easier to retrieve and/or express in the absence of specific cues, but this effect was graded, with no evidence of a step-like cut-off at 18 months or 2 years before testing. In brief, our findings are consistent with the view that the deficits in semantic dementia are predominantly or exclusively semantic, rather than involving the storage of autobiographical memories per se.

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IH died on 31st August 2002, 7 years after he was first seen by MDK. We are all extremely grateful for the help that he and his family gave us in those years.

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Semantic dementia is a form of progressive lobar atrophy characterised by the gradual and relatively circumscribed breakdown of semantic memory. In the neuropsychological literature, semantic memory is typically defined as knowledge not only of word meanings, but also of nonverbal conceptual representations of objects and general world knowledge (Saffran & Schwartz, 1994). Patients with semantic dementia typically show increasing problems in remembering the names of objects, people, and places; in understanding words and sentences; and in recognising objects, faces, and other meaningful stimuli. By contrast, these patients have far less difficulty in the nonsemantic aspects of language use (e.g., phonology, syntax), at least until very late into the progression of the disorder, and they have relatively preserved visuospatial, nonverbal reasoning, and mathematical skills (Cappelletti, Butterworth, & Kopelman, 2001; Hodges, Garrard, & Patterson, 1998; Hodges, Patterson, Oxbury, & Funnell, 1992; Mesulam, 1982; Snowden, Goulding, & Neary, 1989; Warrington, 1975). One of the most striking characteristics of semantic dementia is the extent to which patients are able to remember or keep track of day-to-day events. They can usually keep appointments, remember recent visits from family and friends, travel around by public transport, and do their own shopping or other errands, even when the semantic impairment is severe. This contrasts with the pattern observed in Alzheimer dementia, where patients are typically very forgetful for recent and current events, often reporting that their memory for childhood episodes is sharper than that for events in recent days, months, or years. The underlying lobar atrophy characteristically involves the inferolateral cortex of the left temporal lobe, although cases of predominantly right temporal lobe atrophy have also been described (Evans, Heggs, Antoun, & Hodges, 1995). A voxel-based morphometric study of six semantic dementia patients found relative sparing of the left hippocampus and variable (sometimes very mild) involvement of the right temporal lobe (Mummery, Patterson, Price, Ashburner, Frakowiak, & Hodges, 2000), although the finding of relatively spared left hippocampal structures was not replicated by Galton et al. (2001).

The clinical observation of good memory for day-to-day events in semantic dementia has been supported by experimental studies, directly comparing recent vs. remote autobiographical memories. Autobiographical memory refers to the recall and recognition of personal incidents and events, specific in time and place, and the ability to travel back mentally in time to these incidents and events. Personal semantic memory refers to knowledge of factual information from one's own life. Snowden, Griffiths, and Neary (1996) and Graham and Hodges (1997) tested three and six semantic dementia patients respectively on the Autobiographical Memory Interview (AMI: Kopelman, Wilson, & Baddeley, 1989). Patients were asked to recall autobiographical incidents and personal semantic facts from three time-periods: childhood, early adult life, and recent life. The semantic dementia patients attained significantly higher scores on the *recent life* section than for the earlier time-periods. On the basis of a further investigation using the Crovitz technique (Crovitz & Schiffman, 1974) in one of their six patients, Graham and Hodges (1997) claimed that the recency effect was, in fact, a "step-function" with a relatively short period of 18 months to 2 years (before testing) in which memories were well-preserved, while all memories that pre-dated this cut-off point were impaired. A recency advantage in semantic dementia has also been claimed for memories of famous people (Hodges & Graham, 1998) and public events (Graham, Pratt, & Hodges, 1998). Taken at face value, these various findings suggest that the deficits in semantic dementia extend beyond the purely semantic domain into aspects of remote autobiographical and "personal semantic" memory.

The well-preserved recent autobiographical memory of these patients is a putative testing ground for theoretical claims about the neural basis of retrograde amnesia (RA: Graham, 1999; Moscovitch & Nadel, 1999). There is an apparent double dissociation between semantic dementia and amnesic patients, particularly those whose disorder results from damage to medial temporal

structures. Amnesic patients characteristically show a temporal gradient ("Ribot effect") with relative sparing of early autobiographical memories and severe impairment of recent memories (e.g., Kopelman, 1989; Kopelman, Stanhope, & Kingsley, 1999; MacKinnon & Squire, 1989; Ribot, 1882; Squire, Haist, & Shimamura, 1989). Indeed, some of the earlier case reports described an RA extending back only 2 to 3 years in patients with severe or moderately severe anterograde amnesia resulting from medial temporal damage (Marslen-Wilson & Teuber, 1975; Milner, 1966; Zola-Morgan, Squire, & Amaral, 1986). Other more recent studies have reported a more variable RA—up to approximately 15 years—dependent upon the extent of medial temporal involvement (Reed & Squire, 1998; Rempel-Clower, Zola-Morgan, Squire, & Amaral, 1996), or even a temporally extensive "flat" RA for autobiographical incidents (Cipolotti et al., 2001; Viskontas, McAndrews, & Moscovitch, 2000).

This putative double dissociation provides support for a model of memory in which the hippocampi and related medial temporal structures are responsible for the learning of new information and the short-term storage of recently acquired information, while longer-term memory is subserved by the temporal neocortex (e.g., Alvarez & Squire, 1994; Graham & Hodges, 1997; Kapur, 1999; Kopelman, 1993, 2000a; McClelland, McNaughton, & O'Reilly, 1995; Murre, 1996; Murre, Graham, & Hodges, 2001; Squire, 1992; Squire, Cohen, & Nadel, 1984). There are variations of this model in terms of the proposed nature of consolidation from short- to long-term storage, in particular the length of time that memories are thought to be dependent on the hippocampi/medial temporal lobes, but they share the common claim that the hippocampi serve a *time-limited* role in the acquisition and storage of memories: After this, storage of episodic memories is assumed to occur in the temporal and/or frontal neocortex. If recent memories are indeed relatively well preserved in semantic dementia, this is consistent with the finding that the hippocampi and related medial temporal structures are relatively spared, at least early in the progression of the disease (Graham & Hodges, 1997; Mummery et al., 2000; although see Galton et al., 2001); consequently, semantic dementia patients are able to acquire new episodic memories and store autobiographical information for a limited period. However, these memories cannot be consolidated for longer-term storage because of anterolateral temporal lobe damage in one or both hemispheres (Graham, 1999; Graham & Hodges, 1997; Murre et al., 2001; Snowden, Griffiths, & Neary, 1996).

However, this view has been challenged by Nadel and Moscovitch (1997), who argued that many patients with medial temporal damage show extensive periods of retrograde amnesia, meaning that the "consolidation" and "temporary" storage provided by the hippocampal system must be implausibly long. Nadel and Moscovitch proposed an alternative ("Multiple Trace") account (Fujii, Moscovitch, & Nadel, 2000; Moscovitch & Nadel, 1998, 1999; Nadel & Moscovitch, 1997; Nadel, Samsonovich, Ryan, & Moscovitch, 2000), stating that there is a continuous interaction between hippocampal and neocortical systems: "the hippocampal complex and neocortex continue to be involved in both the storage and retrieval of episodic memory traces throughout life" (Nadel & Moscovitch, 1997, p. 222). In a subsequent review, Fujii et al. (2000) argued that damage to the hippocampal complex (as opposed to the "hippocampus proper") was required to give an extensive RA: According to their definition, the "hippocampal complex" includes most of the medial temporal grey matter neocortex (except for the amygdala). Support for multiple trace theory is provided in the lesion studies of Viskontas et al. (2000) and Cipolotti et al. (2001), as well as in some functional imaging studies showing equivalent hippocampal activations in the retrieval of remote and recent memories (Conway et al., 1999; Ryan et al., in press). However, a problem with the lesion studies is that many of the cases reviewed had evidence of concomitant pathology elsewhere (Kopelman, 2000b), and not all functional activation studies show equivalent "remote" and "recent" hippocampal activation across all tasks (Haist, Bowden Gore, & Mao, 2001; Mayes & Roberts, 2001).

Moscovitch and Nadel (1999) suggested a number of ways in which the semantic dementia data could be explained within their model. For example, if semantic dementia patients have a degree of frontal as well as antero-lateral temporal lobe degeneration, this could lead to difficulty in *retrieving* older memories. Frontal pathology can indeed produce retrograde amnesia (Della Sala, Laiacona, Spinnler, & Trivelli, 1993; Kopelman et al., 1999), although more recently Nestor, Graham, Bozeat, Simons, and Hodges (2002) have reported differences in the autobiographical memory profiles of patients with semantic dementia and those with the frontal variant of fronto-temporal dementia. Less obviously, perhaps, the step-like recency effect also poses problems for the "time-limited" account: We have to reconcile the fact that the time period of preserved memory in semantic dementia is said to extend back only 18 months to 2 years with the very variable observations on the extent of RA in patients with medial temporal lesions (see references above). Graham et al. (1998) hypothesised that the 2-year temporal cut-off might be specific to semantic dementia because these patients would show abnormally fast forgetting of hippocampal memories as a result of their severe cortical atrophy.

Kopelman (2000b) argued that, before accepting the Graham–Hodges explanation of the findings in semantic dementia, alternative possibilities should be considered. First, semantic dementia and amnesic (or Alzheimer) patients may fail autobiographical memory tasks for different reasons: The semantic dementia patients because they lack the conceptual and linguistic skills to retrieve *and describe* past autobiographical episodes as defined above. If Alzheimer patients could be matched for the severity of semantic memory impairment to semantic dementia patients, they might perform identically in retrieving early memories (childhood, young adult). Second, in the Snowden et al. (1996) and Graham and Hodges (1997) studies, the semantic dementia patients differed most markedly from Alzheimer patients in the retrieval of *recent* autobiographical incidents, and it might be more parsimonious to suggest that current everyday experience provides retrieval cues for recent autobiographical memories in semantic dementia patients (compare Snowden et al., 1996). Third, it seems implausible that memories should be stored exclusively in the hippocampi/medial temporal lobes for 2 years, at which point they move across to the antero-lateral temporal neocortex. Much more plausible would be a dynamic interaction between the hippocampi/medial temporal lobes and the temporal neocortex during this initial period, in which case one would have predicted greater impairment in recalling recent autobiographical incidents than was observed, unless some other phenomenon (such as everyday cueing) was operating. Fourth, these patients commonly have a degree of concomitant frontal pathology (being a variant of the fronto-temporal dementias) and, as Nadel and Moscovitch (1997) had suggested, an impairment in strategic retrieval might contribute to the particularly severe deficit in more remote memories (but see Nestor et al., 2002). Finally, it was noted that the reversed temporal/Ribot gradient in semantic dementia was much more convincing for autobiographical tasks than for the more semantic aspects of remote memory. On a famous names test reported by Hodges and Graham (1998), there was a ceiling effect by controls in a recognition condition and no significant difference between the earliest and most recent time period in four out of five patients, and there was a floor effect in four out of five patients in an "identification" condition. The curves looked flat, and group by time-period interaction effects were not reported. In brief, it is plausible that the semantic dementia patients" problem is indeed predominantly semantic/linguistic and/or strategic: They lack the language to describe early autobiographical and other remote memories and the strategies to retrieve them, whereas recent autobiographical memories (but not necessarily "more semantic" public information) are cued by environmental experience and context in a manner analogous to that described by Snowden et al. (1994; Snowden, Griffiths, & Neary, 1995; and also Funnell, 2001) in analysing these patients' conversational speech.

In other words, semantic dementia patients have great difficulty in understanding the meanings of words, and in selecting and producing the appropriate words to express meaningful concepts. Tests

of autobiographical memory typically rely on asking people to recount an incident in response to a given word or question, e.g., "tell me about where you went to school as a child." A person who has difficulty understanding the words "child" and "school" is clearly going to have problems here. Even if these concepts are successfully understood, there may be difficulty in finding the words to describe the relevant episode. The patient could have some memory of breaking their leg in the playground and being taken to hospital, but this will not count towards their score on an autobiographical memory test if they are unable to produce the words *playground, teacher, hospital,* or even *leg*. Crucially, we suggest that the semantic deficit of semantic dementia patients may interact with the age of the autobiographical incident, such that words and concepts relevant to older incidents may be less accessible than those related to very recent and current happenings. This suggestion is supported by the findings in several studies by Snowden and colleagues, which demonstrated that concepts relevant to current experience are *invested with meaning* and well preserved, relative to words and concepts that are no longer part of the day-to-day experience and conversation of the patient (Snowden et al., 1994, 1996; Snowden, Griffiths, & Neary, 1999). Further evidence that repeated current exposure to words can lead to "reactivation of semantics" comes from vocabulary relearning studies, in which semantic dementia patients demonstrated retention of object names for several months, when they were able to use temporo-spatial cues to facilitate learning (Snowden & Neary, 2002; see Funnell, 2001, for discussion).[1]

It is true that currently relevant concepts may not be *perfectly* preserved: Patients are often only able to employ them in limited contexts and in ways specific to their own experience, no longer appreciating their broader or more abstract meanings. For example, a patient may understand "oil" as something that is delivered to their door and is put in radiators, but may no longer have any understanding of what oil is or where it comes from (Snowden et al., 1996). Funnell (2001) has interpreted such phenomena within an account of semantic memory, not as an independent abstract system but as a continuum of levels of meaning from the most context-bound scripts for specific events to the most abstracted and context independent, suggesting that semantic dementia patients are increasingly reliant on the more specific, context-bound levels as the higher, more abstract levels of knowledge break down. But it is exactly these contextually constrained, personally relevant aspects of meaning that are required (and suffice) for the generation and description of autobiographical incidents. Consequently, we would expect an advantage for incidents that can be accessed and recounted using words for names, places, and activities that are relevant to current experience—which will generally be the more recent ones. On this account, it might be possible to aid patients by providing them with the names of relevant people, places, and other specific words, and this facilitation might affect both the retrieval of the stored memory trace and the verbal expression of the recollected episode. On the one hand, specific names or other cues might allow access to the context-bound semantic representations that are thought to be relatively intact for semantic dementia patients (Funnell, 2001), and these representations might, in turn, trigger related autobiographical memory traces. In addition, providing relevant words for the patient to use may help to overcome word-finding problems that make verbal expression of the recollected episode difficult. If this hypothesis were correct, cueing might benefit older memories to a greater extent than recent memories, since current events are already benefiting from the availability of relevant vocabulary.

In a recent study, published since the inception of the current research, Westmacott, Leach, Freedman, and Moscovitch (2001) have reported data consistent with our hypothesis that autobiographical memory retrieval by semantic dementia patients

[1] Even if the same cue words are used to probe different time periods (as in the Crovitz technique) so that comprehension demands and retrieval cues are held constant, the greater availability of currently relevant names and words could facilitate the patient in describing recently occurring events, and thus could still explain the recency effect.

may be determined at least partly by their lexical semantic deficits. Westmacott et al. explored this issue by presenting pictorial cues rather than purely verbal ones for the recall of episodes. Semantic dementia patient EL was able to demonstrate specific knowledge about the events shown in family photographs, locating the events accurately in time and space for all periods across his life span, including the most remote. Although there was no recency advantage for episodic recall, there was a clear effect in this direction in EL's ability to *name* individuals in the photographs, suggesting that the availability of lexical information (including proper names) is dependent on current autobiographical experience (although see Graham, Kropelnicki, Goldman, & Hodges, in press, for a recent report that a similar picture-based cueing method did not facilitate retrieval for their semantic dementia patient, AM). The motivation for our study was very similar to that of Westmacott et al. (2001), although we have accessed remote memories via increasingly specific lexical cues, rather than by pictorial cues.

A related issue is whether the recency effect in semantic dementia (if it occurs) is genuinely step-like rather than gradual. The 18-month/2-year cut-off for autobiographical memories relies on evidence from a single case study of patient AM (Graham & Hodges, 1997), using one particular technique (the "Crovitz" test). They found that the majority of the incidents recalled by AM in the most recent time period came from the 18 months before testing. Although a similar period of preserved memory for *public* events was found in a second patient, DM (Graham et al., 1998), further evidence is clearly needed to determine whether the step function is reliable across patients and testing methods. Differing interpretations are possible, dependent upon whether the function is truly step-like or more gradual. For example, Snowden et al. (1996) stated: "We would suggest that the key factor in determining the quality of a concept or a memory is not its age but its relevance to contemporary ongoing experience" (p. 1130), thereby explicitly rejecting the notion of a sharply delineated temporal cut-off. On the other hand, if we do find that the step-like function is a reliable effect, it will be necessary to carry out detailed testing to establish exactly where the temporal cut-off lies and whether it is consistent across patients.

THE CURRENT STUDY

In this study, we report results for a semantic dementia patient on (1) standard tests of autobiographical and remote memory and (2) a new test that we have developed in which the patient is given increasingly specific cues relevant to important episodes from different periods in his life, ranging from childhood through to just a few weeks before testing. The use of graded cues for each event allowed us to test whether remote memories were genuinely lost or whether they were difficult to access as a result of comprehension, retrieval, and/or output deficits. If the patient were aided by the cueing technique, we would be able to determine whether a recency effect remained and, if so, whether it was step-like or gradual across the different time-periods.

We report data for patient IH, who was referred to the Neuropsychiatry and Memory Disorders clinic at St Thomas' Hospital towards the end of 1995. Clinical observation prompted us to explore the nature of IH's autobiographical memory and to carry out the present study. We were surprised to find that, in spite of being a classic case of semantic dementia in every other way (see below), he was able to entertain us with anecdotes from as far back as his late teens. Although severely hampered by his word-finding difficulties, he was an enthusiastic and entertaining raconteur, even though his scores on formal semantic tests approached floor level. For example, IH often talked about a Test Match he attended at 16 or being selected for the RAF, an event which took place when he was 18 years old. Here is his account of how the selection procedure for pilots whittled down the applicants from 24 people to the final 4.

> Once again, 24 came round on Romford for a week, and on my first day they delved into 24 and 5 were put aside, come up the north, . . . come out, put aside, put aside this, and then the next day another four were put aside and then I came up with the, with the 4 on Friday of that week and they delved into . . .

so, 24, 20 put aside and just 4, and I was one of those 4 and the final, and come up on this and it was quite pleasant on that / internal?/

Ooh it was marvellous, they delved into each day, ooh and I come up with now—pilot! Pilot? Ooh heavens, and they personally want me personally to come up with pilot over 3 years, not 2, and come up with these four individuals—they delved into me personally, smiled and said "if you want to come up with pilot, don't come up with 2 years, come up with 3 on that" and I delved into something on a regular basis at that time and I put that aside . . . phwor, heavens, but I wanted to come up all these years in the past, the pilot, marvellous . . .. Oh I should have come up with pilot, definitely. I should have come up with the RAF for 3 years, but I delved into business and everything and come up on that at that time and 1940's . . . 50's, so I came up with the 2 years on that and er . . ."

IH's story-telling prowess seemed at odds with the view that patients with semantic dementia have impaired memories for remote events. Moreover, like Westmacott et al.'s (2001) patient, IH was able to use family photographs and other materials (certificates, cards) to aid his memory. The fact that IH was far more fluent on informal, unstructured conversations than would be expected given his poor performance in formal tests of word comprehension and naming was very reminiscent of the observations by Snowden et al. (1999) that concepts related to current autobiographical experience are relatively preserved: These concepts form the basis for most everyday conversations. In addition, we observed that in normal conversation (but not formal testing), listeners provide lexical cues for patients to use. Only the stoniest of souls can chat with a patient who is struggling to relate a story "Yesterday I popped round to see my . . . , not mother, the other one, the, oh what is it, oh I've forgotten now, what was I talking about, is it a /si/ . . ." without offering "*you went to see your father? no? your sister? You saw your sister?*" At which point the patient will gratefully exclaim "s*ister! that's it, I popped round to see my sister*" and can, at least sometimes, carry on with the story, rather than continuing to chase the word sister round and round, while forgetting the point of the story. Such lexical cueing is not allowed in formal testing, of course, where the point is to see whether the patient can retrieve a word without help.

CASE HISTORY

At the time of this investigation (1998/9), IH was a 65-year-old right-handed ex-financier with a 9-year history of progressive difficulty in word-finding, reading, naming, and language comprehension. He was diagnosed as having semantic dementia in 1995, based on clinical observation and his low scores on tests of language production and comprehension in the context of good nonverbal reasoning, visual spatial processing, and day-to-day memory and orientation. For example, he was able to remember and keep appointments at the hospital and to find his way across London by public transport: One striking example of his good everyday memory was that he was relied upon by family and friends to feed their pets each day while they were away on holiday. IH also had remarkably well-preserved arithmetical processing abilities and reading and writing of number words, as documented elsewhere (Butterworth, Cappelletti, & Kopelman, 2001; Cappelletti et al., 2001; Cappelletti, Kopelman, & Butterworth, 2002). Although his speech was characterised by severe word-finding difficulties and was semantically impoverished, it was fluent and did not reveal obvious phonological or syntactic difficulties. IH initially showed a pattern of surface dyslexia in reading, consistent with many previously reported cases of semantic dementia (e.g., Hodges et al., 1992). Representative scores on neuropsychological tests of linguistic and other cognitive functions are listed in Table 1. As can be seen from the table, even at the earlier time slice (1996), IH was already severely anomic (40% correct on the Snodgrass & Vanderwart, 1980, picture set) and also impaired in a nonverbal semantic comprehension test (Pyramids and Palm Trees, Howard & Patterson, 1992). Since 1995, IH's language has continued to decline, and this is also shown in Table 1. However, his functioning on nonlinguistic reasoning and problem-solving tasks has remained at a high level (note especially his high scores on Raven's matrices and the modified card sorting task in Table 1).

An MRI scan in 1995 revealed severe atrophy of the left temporal lobe. A repeat scan (Figure 1)

Table 1. *Background neuropsychological data for IH: 1996–1999*

	IH: No or % correct		
Measures	*1996*	*1998/9*	*Normative data*
Raven's (1965) Coloured Progressive Matrices	26/36	32/36	50–75th percentile
Digit span		5 forward/4 back	
Modified card sorting test (Nelson, 1976)			
Categories attained	6/6	6/6	Mean = 5/6 (*SD* = 1.66)
Total errors	6	6	Mean = 9.2 (*SD* = 8.5)
Perseverative errors	1	1	Mean = 5.2 (*SD* = 3.9)[a]
No. cards used	42	44	48
Recognition Memory Test (Warrington, 1984)			
Words	52%	–	<1st percentile
Faces	82%	52%	<40th percentile <1st percentile
Graded naming test	0	0	NART-R IQ <69
(McKenna & Warrington, 1983)			
Picture naming	40%	0	Mean for older control group
(Snodgrass & Vanderwart, 1980)			89% (range 79–97%)[b]
CSL colour photo naming (Bunn et al., 1998)			
Living things		4%	Control mean = 95% (*SD* = 5%)
Non-living objects		12%	Control mean = 95% (*SD* = 2%)
Verbal fluency (Benton & Hamsher, 1976)			
FAS test I	8	0	<1st percentile
PALPA Reading test (Kay et al., 1992)			
Regular words	92%	76%	
Irregular words	74%	40%	
Word repetition		87%	
Pyramids and palm trees (Howard & Patterson, 1992)			
3-picture version	86%	Chance level	98–99%
CSL word-picture matching (Bunn et al., 1998)			
Living things		27%	Control mean = 100%
Non-living objects		56%	Control mean = 100%
TROG (Bishop, 1983)		5 blocks passed	Age equivalent = 4 yrs

[a]Nelson (1976) reports the breakdown of error types only for controls who attained five or fewer categories. These figures are for this group. No control data are given for those who, like IH, attained all six categories.
[b]Control mean and range based on data collected from older age subject group at Centre for Speech and Language.

obtained in October 1998, within a few months of the experimental study reported here, showed marked atrophy of the left temporal lobe with relative preservation of the left hippocampus, although (as in virtually all published cases) the hippocampus was not entirely normal. The right temporal lobe showed only minor atrophy, as did the rest of the neocortex. There was, at most, minimal change between the scans of 1995 and 1998. In brief, the clinical observations, neuropsychological profile, and MRI findings in IH were entirely consistent with a diagnosis of semantic dementia.

AUTOBIOGRAPHICAL MEMORY INTERVIEW

Method

The first step of our experimental study was to an attempt to replicate the findings of Snowden et al. (1996) and Graham and Hodges (1997) on the Autobiographical Memory Interview (AMI: Kopelman et al., 1989). The AMI asks questions about childhood, early adulthood, and recent life, probing autobiographical incidents (e.g., *tell me*

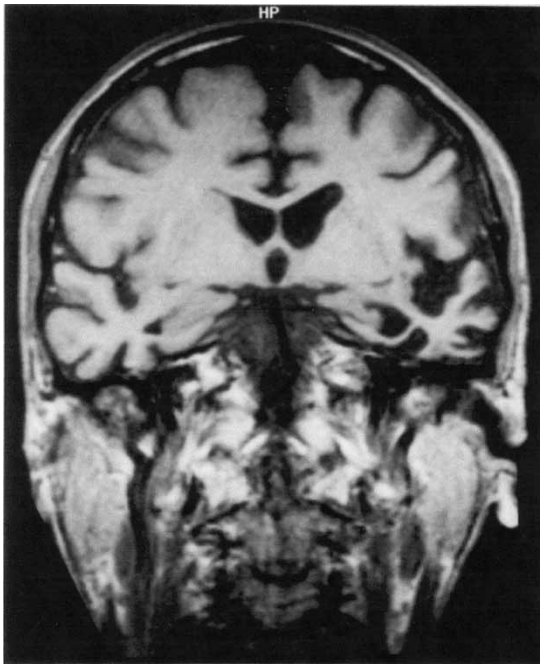

Figure 1. *MRI scan for IH, October, 1998 showing severe left temporal lobe atrophy and only mild/moderate atrophy elsewhere in the brain including the right temporal lobe. (Note: Left is shown on right of the scan.)*

about something than happened in your first job) and personal semantic information (e.g., *tell me the address of your house as a child*). It has been widely employed in studies of amnesia (e.g., Kopelman et al., 1999) and Alzheimer patients (e.g., Kopelman, 1989). IH was tested in 1996 and again in 1999. Control data were taken from the Kopelman (1989) study (N = 16; mean age = 61.75, SD = 13.15). In addition, IH's scores were compared with those of the 6 Alzheimer patients (out of 16) from that study who performed worst on two measures of semantic memory: FAS verbal fluency (Benton, 1968) and accuracy (*not* speed) on a sentence verification test ("silly sentences": Baddeley, Emslie, & Nimmo-Smith, 1992). IH scored 8 when first tested on FAS verbal fluency; the six Alzheimer patients, whose mean age was 70.3 (± 3.2), had a mean score of 10.7 (± 3.5). On the sentence verification test, IH scored 33 out of 50 when not given any reminders of the task instructions. When tested a few weeks later and given frequent explanations and reminders of the task instructions he scored 41.The Alzheimer group had a mean score of 40.2 (± 1.7) without reminders. Hence, on these measures of semantic memory, IH performed worse than the Alzheimer group, but his scores were within 1 SD of theirs on two out of three measures. (The Alzheimer patients had a mean NART-R estimated premorbid IQ of 102.3, SD = 7.3, and a mean WAIS-R current Full Scale IQ of 85.0, SD = 7.8, as well as episodic memory deficits, but the purpose here was to compare a sample of Alzheimer patients matched as closely as possible to IH on semantic tests, unlike previous studies where unmatched AD/SD comparisons have been made.)

In the two earlier studies (Kopelman, 1989; Kopelman et al., 1999), amnesic and Alzheimer patients had been tested on measures involving the recall and recognition of famous news events from photographs. In the present study, IH's performance for news events from the previous five decades (50 items) was compared with that of the Alzheimer subgroup (N = 6) with broadly comparable semantic memory scores.

Results

Figure 2 shows the number of correct answers for IH on the AMI in 1996 and in 1999. IH's personal semantic score (upper panel) shows a clear advantage for the recent life condition (max. score = 21) compared to the two earlier time periods, with only minor change between the 1996 and 1999 test sessions. IH's recent life score was significantly higher than his childhood score, 1996, $\chi^2(1) = 12.7$, $p < .001$; 1999, $\chi^2(1) = 6.15$, $p < .01$, or early adult score, 1996, $\chi^2(1) = 6.46$, $p < .01$; 1999, $\chi^2(1) = 4.02$, $p < .05$. The pattern is similar for the autobiographical incidents (lower panel), at least at the 1996 test session, with a higher score for the recent time period (max. score = 9) than for the two earlier conditions—although the difference is nonsignificant. In 1999 the early adult score was now comparable with the recent life score but both were better than the childhood score, indicating an advantage of more recent over remote autobiographical memories, although, again, these differences did not reach

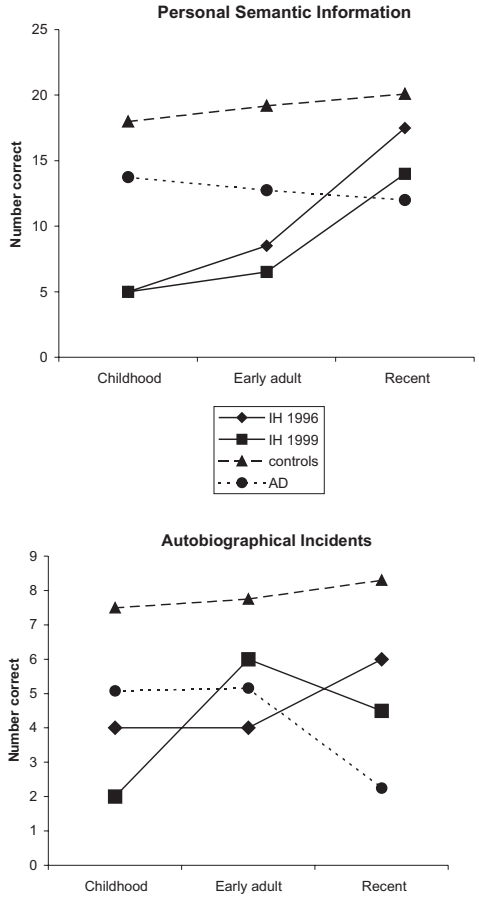

Figure 2. *Scores for IH, healthy control group, and Alzheimer subgroup on the Autobiographical Memory Interview (AMI). The upper panel shows the scores for the Personal Semantic section (maximum score = 21), and the lower panel shows the scores for the Autobiographical Incidents section (maximum score = 9). Control and Alzheimer data from Kopelman (1989).*

statistical significance. The data from the personal semantic schedule, but not the 1999 autobiographical incidents' finding, would be consistent with a step-like function in that the recent life scores were significantly better than the earlier scores, but the step-like nature of this effect must be treated with considerable caution, given that there is a period of up to 40 years between early adult life and recent years for IH. In summary, IH showed a pattern of better recent than remote recall in this task, consistent with previous reports for semantic dementia patients. Whilst we acknowledge that the recency effect was nonsignificant in the Autobiographical Incidents section, this is perhaps not surprising given the lack of power of the analysis for a single subject, with only nine questions per time period. However, we would emphasise that IH's pattern of data accords with that of previously reported cases, with scores at each time point that are very closely similar to the means of the semantic dementia group reported by Graham and Hodges (1997).

As published previously (Kopelman, 1989), a group of 16 Alzheimer patients showed a "gentle" but statistically significant temporal gradient (Ribot effect) across both components of the AMI. Figure 2 shows that the present subgroup of six Alzheimer patients exhibited the same pattern. In 1996, IH's scores for childhood and early adult incidents were broadly comparable with those of the Alzheimer subgroup. However, his 1999 childhood incidents score was worse than that of the Alzheimer subgroup as were his childhood and early adult personal semantic scores, although the Alzheimer group showed large standard deviations across all these measures.

On the recall of famous news events (Figure 3, upper panel), IH's performance was closely similar to that of the Alzheimer subgroup, both groups performing close to floor without any evidence of a recency effect or step function. On the recognition of news events (Figure 3, lower panel), IH showed a fluctuating pattern of performance across the decades, but his overall scores were intermediate between the controls and the Alzheimer subgroup. His scores for the most distant and recent decades were identical (60%; chance = 20%), i.e., there was no evidence of a step-function.

Discussion

These initial results broadly replicate those of Snowden et al. (1996) and Graham and Hodges (1997), showing a recency effect (reversed temporal gradient) across both components of the AMI. This recency effect was in stark contrast to the performance of an Alzheimer group, matched to IH as best we could on two semantic memory measures, who showed a conventional temporal (Ribot) gradient relative to controls (Figure 2 and Kopelman,

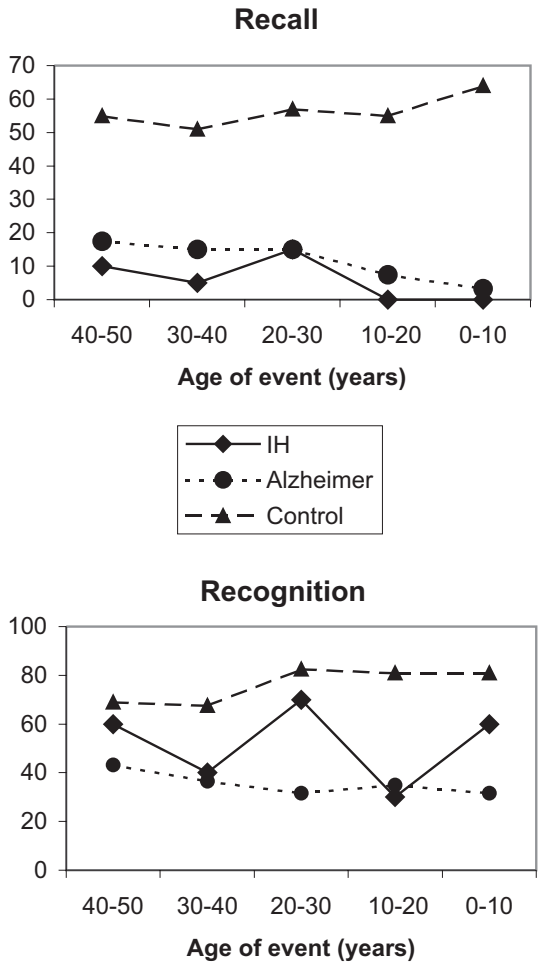

Figure 3. *Famous News Events test: Recall scores (upper panel) and recognition scores (lower panel) from the same subjects as Figure 2.*

1989). By contrast, IH did not show any evidence of a recency effect on a news events test (recall or recognition). Although it might be argued that a decade is too wide a timespan to obtain a step function hypothesised to occur over 18 months to 2 years, this latter finding is broadly consistent with the reported data from four out of five semantic dementia patients on Hodges and Graham's (1998) famous names identification and recognition tasks. Hodges and Graham argued for a step function on this task, but their argument was largely based on the performance of a single case, their fifth semantic dementia patient. If indeed it is harder to obtain a recency effect in semantic dementia patients on "more semantic" remote memory tests than on autobiographical tasks, as we would argue that both our data and those of Hodges and Graham (1998) suggest, this is easier to explain in terms of the effect of environmental/contextual cueing of recent autobiographical memories than in terms of a step function arising from hippocampal/neocortical transfer of memories. This issue will be taken up again below.

CUED AUTOBIOGRAPHICAL MEMORY INTERVIEW: PART 1

A cued autobiographical memory test was designed to address a number of issues. Questions were included from many different points in IH's life in order to investigate the temporal gradient of autobiographical memory at a more fine-grained level than is possible with the AMI, which groups memories into only three time periods. A close family member was interviewed in order to identify and date 17 salient incidents from IH's life, ranging from childhood to a few months before testing. Examining the quality of IH's recall of these incidents would allow us to determine whether the temporal gradient was gradual or step-like. By identifying specific incidents and gathering extensive information about each one, we were able to construct a set of increasingly specific cues for information pertinent to each incident. In turn, this allowed us to assess the effectiveness of lexical cueing on IH's ability to generate episodes, and whether any cueing effect interacted with the age of memories, resulting in a greater benefit for more remote memories.

Method

IH's former wife (JH), who was still very close to him, agreed to help with this. She was interviewed by one of the experimenters and asked to recall as many salient incidents as she could from IH's life, starting with childhood and working through to the current time. Throughout the interview, JH was

probed for as much information as possible about each incident, including the names of people and places involved and for precise dates where possible. The interview was tape-recorded and later transcribed. From this interview, a set of 17 episodes were chosen which: (1) covered as many different stages in IH's life as possible—there were approximately two incidents from each decade; (2) had elicited a sufficient amount of information to provide a set of increasingly specific cues (described below); and (3) were judged by JH to be very salient events in IH's life.

Once we had selected the incidents, we constructed a set of cues. There were six cues per incident, increasing in the specificity of the words provided. These were as follows, with an example of each type of cue from one particular episode.

a. General cue for the time period from which the memory should be generated: "Can you tell me about something that happened in your late teens or when you were about 20?"
b. General cue as to what the memory could be about: "Can you tell me about something that happened to do with your occupation in your late teens/or when you were about 20?"
c. Specific cue about an incident, providing some key words: "Can you tell me about when you went to study at college?"
d. Specific cue with additional information and one or two more specific key words: "Can you tell me about when you studied accountancy at college?"
e. Forced choice: "Can you tell me whether you studied accountancy at Cardiff, Oxford, or St Helens?"
f. Cue for date (if not given already): "Can you tell me which year this happened?"

Examples of the cues for a further three of the incidents are given in Appendix A. The form of the questions was kept the same across incidents, and as far as possible, the amount of information and the specificity of the cues at each level was equated over incidents, although the exact words were clearly constrained by the nature of the event being probed. The forced-choice question was given as the most specific level of cueing and provided an opportunity for IH to indicate a memory of a specific place, person, or event without necessarily having to retrieve or produce any lexical information himself. This was achieved by presenting IH with the three choices in written format. The experimenter always helped IH to read the words (although in many cases he was able to do this alone). IH was allowed to indicate his choice by pointing if necessary (although in practice, he was almost always able to repeat and recognise the words once he had read them, or heard them read aloud). In addition to the correct choice, two distracter words were given, both of which were plausible alternatives and were familiar to IH. For example, in the above incident, we provided the correct place (IH studied in St Helens) and the distracters were Oxford (a plausible place to study and a city where he had lived for many years), and Cardiff (where one of his children studied). Thus, IH would need to identify the city that was specifically connected with this episode rather than simply choosing on the basis of familiarity alone. At the end of each episode, IH was also asked if he could remember the time/date of the incident if this information had not already been given.

Procedure

The test was administered in two sessions lasting several hours, which were separated by approximately 2 weeks. IH was interviewed in his own home by one of the experimenters. Each session was recorded on audiotape and videotape for later transcription. The experimenter explained that he would be asking some questions about IH's life and would like him to talk about his memories as much as he could. The style of the interview was kept as informal as possible within the constraints set by the hierarchy of lexical cues for each episode.

For each incident, the experimenter started by asking the first cue question (e.g., "Can you tell me about something that happened when you were a child?"). IH was then encouraged to give any information he could at this level of cueing, before moving onto the next cue (e.g., "Can you tell me about anything that happened when you were a child to do with school?"). In between these cues, encour-

agement was in the form of general questions such as "Can you remember anything more about that . . . anything else" and in repeating and summarising IH's comments to keep him focused (e.g., "So, when you were at school, you did . . . what?"). Cues were also repeated as often as necessary as long as IH still seemed to be trying to retrieve relevant information. As far as possible, no additional lexical cues were provided other than those in the test script. However, where IH was clearly struggling to retrieve a specific word—often with mimes and gestures—the experimenter tried to guess what that word was in order to enable the conversation to move along. Most of these points are illustrated in this extract from IH's story of playing rugby at school when he was 12 years old.

Exp: Tell me about playing rugby at school?
Can you tell me about rugby at school?
IH: Ooh, with regard to that, I came up with the . . . I delved into that *(mimes diving to the floor to score a try*). Come up with that name now!
Exp: Rugby, at school?
IH: No, delve into rugby (more miming) and I came up with a /fy?/ and all that as well . . ..
Exp: A scrum?
IH: No!
Exp: A try?
IH: Try! Oh well done, I came up with on a regular basis, and a try, with regard to, we came up on this, outside, to London as well, from Oxford, on the Saturday, came up, to another one, and delved into and I came up with a /fy/ and all that . . . I came up with that in the final minute (*lots more try-scoring mimes*). Try! Try?
Exp: Yes.
IH: Ah, well done, that's rugby.

Occasionally, the more open-ended general cues at the start of each episode led to IH recounting a story other than the one we had in mind. In this case, IH was allowed to continue to give as much information as he could before moving on to the next cues, which would eventually specify the target episode. We later checked with JH to ensure that the information was accurate and, if so, it was added to the score for the appropriate time period.

Scoring of responses

We adopted two methods of scoring the responses generated by IH. The first was a count of the number of pieces of information or facts given by IH for each incident at each level of cueing. These were initially identified and counted independently by two of the experimenters. There was a high level of agreement between the raters (over 90%), and the remaining discrepancies (concerning, for example, whether something counted as one piece of information or two) were resolved through discussion. The count included both personal semantic information (e.g., "we lived near Oxford then") as well as strictly autobiographical incidents ("My mother came over"), since the claims about the memory profile in semantic dementia have not made any clear distinction between these two potentially different kinds of memory.

The second scoring method was the 0–3 rating scale used in the Autobiographical Memory Interview (Kopelman et al., 1989, 1990). The maximum score is 3 for an episodic memory specific in place or time, going down to 2 for a personal but not specific event, or a specific event but time and place not recalled, 1 for a vague personal memory or one based largely on semantic memory, and 0 for no response. Half-points are permitted. A separate score was allocated to IH's response for each target episode at each level of cueing. The set of incidents was scored by a third experimenter. This form of rating is derived from that used in the Crovitz-Galton paradigm (Crovitz & Schiffman, 1974; Zola-Morgan, Cohen, & Squire, 1983), and was employed by Graham and Hodges (1997).

Control subjects

We also tested three control subjects on a modified version of the cued autobiographical memory interview. We recruited three men of a similar age (61–70) and level of education to IH, all of whom had experienced broadly similar life events, in that they were married, with grown-up children, had done military service, and had spent most of their lives living and working in the South of England. Rather than construct individual tests for each subject, we based the control test on the 17 episodes used with IH. The cues were changed slightly to make them broad enough to be relevant

to almost anyone. For example, we asked questions about the kinds of sports they played at school, their college/apprenticeship years, military service, marriage and birth of children, family illnesses, family holidays, deaths of parents, and so on. All 17 of IH's incidents were used, with questions starting with a general cue specifying the time period the memory should come from (e.g., Can you tell me something that happened in your 20s?), and the questions were evenly distributed across the lifespan, as they were for IH. We were not able to include the more specific cues, such as names of people and places relevant to each incident. However, in almost all cases, control subjects were able to produce detailed autobiographical memories of specific episodes even without the more specific cues (as we would expect for people who do not have a memory impairment).

RESULTS

Information score

We counted the number of pieces of information given for each event at each level of cueing by IH and the control subjects. These data are recorded in Table 2, showing (left) IH's scores and (right) the corresponding means for the controls.

Figure 4 (upper panel) shows IH's scores and the mean performance of controls in response to cues a and b only. IH's scores were generally at "floor" and more than 2 *SD*s below those of the controls. There was a suggestion of a small increase in the information that IH recalled for ages 26–35, years consistent with findings of a reminiscence bump for the early adult period in the normal population (e.g., Rubin, 1982), although this was not statistically

Table 2. *Cumulative information score for IH and controls*

	IH							*Control means*				
	Cue level							*Cue level*[b]				
Date of event	*a*	*b*	*c*	*d*	*e*	*f*	*Order of event*[a]	*a*	*b*	*c*	*d*	*f*
1946	3	3	5	8	9	12	1	5.0	12.3	19.7	21.0	22.0
1953	0	0	4	7	21	21	2	7.3	15.0	23.0	25.0	26.0
1954	0	0	2	3	3	3	3	7.0	14.3	23.0	23.7	24.3
1957	1	1	6	15	15	28	4	3.7	6.7	13.3	15.0	16.0
1958	0	0	0	11	12	12	5	7.0	13.3	18.7	19.0	19.7
1963	3	10	10	15	15	15	6	4.0	5.0	7.7	9.0	9.7
1967	1	10	10	15	16	16	7	8.0	12.3	17.3	19.7	20.7
1971	0	0	6	18	18	18	8	6.7	12.0	21.3	22.0	23.3
1978	1	3	6	12	13	13	9	8.3	14.3	20.3	22.0	22.7
1982	7	7	8	20	20	20	10	7.0	10.7	14.0	14.3	15.0
1983	0	4	13	13	14	14	11	8.3	9.7	15.0	15.0	15.7
1987	0	1	16	16	18	18	12	8.5	12.5	16.0	16.0	17.0
1988	0	0	0	0	0	0	13	4.7	8.3	17.0	17.7	18.7
1991	0	4	24	25	29	29	14	4.3	12.3	18.0	18.7	19.7
1993	0	1	4	6	10	11	15	4.7	12.0	14.0	14.7	15.3
1996	0	0	8	25	28	28	16	10.3	15.7	21.0	22.7	23.0
1998	0	4	13	14	15	15	17	10.0	20.3	25.3	28.3	28.7
Mean	0.9	2.8	7.9	13.1	15.1	16.1		6.8	12.2	17.9	19.0	19.8

[a]Events are listed in chronological order, since individual dates of remembered events varied across the three control subjects.
[b]Control subjects did not receive the multiple choice questions that made up cue level e for IH.

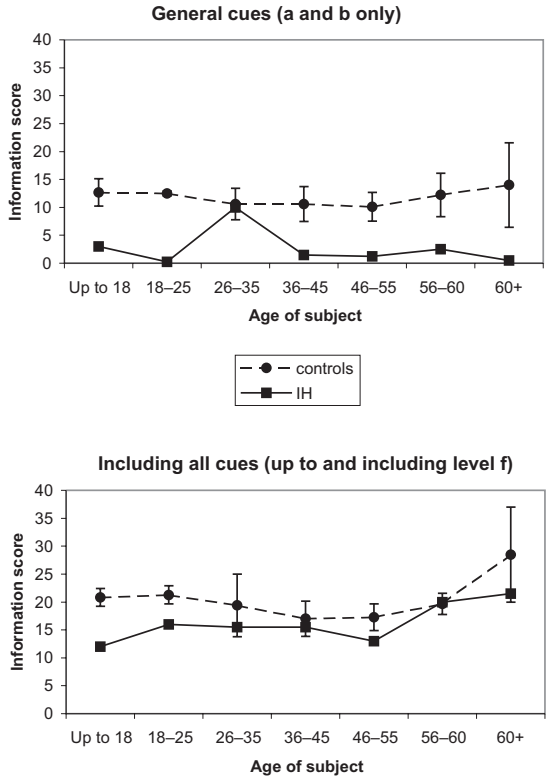

Figure 4. *Information scores for IH and controls showing overall contrast between responses to general cues and more specific cues. The upper panel shows information scores for general cues (a and b) while the lower panel shows information scores for all cues, up to and including the most specific level, f. To simplify the plot, the 17 events have been grouped into 6 bands according to the age of the person at the time of the event. Error bars show 1 SD above and below the mean for the control group.*

significant. Figure 4 (lower panel) shows IH's scores and controls' scores using all cues up to and including level f: When cued to this extent, IH could retrieve autobiographical memories more successfully, and his scores were now generally within 1 *SD* of controls. However, IH's scores were below 2 *SD*s of the control mean for the earliest two datapoints.

Figure 5 presents the information scores at each cue level (see also Table 2). The statistical analyses of these findings will be presented separately for controls and IH.

Control subjects (upper panel). Mean cumulative information scores for each event at each level of cueing (i.e., the information count up to and including that cue) were entered into an analysis of covariance (ANCOVA). The level of cueing was a repeated measures factor with five levels (a, b, c, d, f: controls did not receive the multiple-choice cues so there was no level e). The age of the memory was entered as a covariate, coded in terms of chronological order from 1 (*oldest*) to 17 (*most recent*).

As would be expected, the control group showed a main effect of cue level, $F(4, 60) = 43.1$, $p < .001$; their cumulative information scores increased from the most general level (a) through to the most specific cue (f). There was no effect of the covariate, age of memory ($F < 1$), nor was there an interaction between age of memory and the level of cueing ($F < 1$). We carried out further analyses to see whether there were any effects of date of event using Pearson correlation analyses. Control subjects showed no significant correlations between amount of information given and age of memory for any cue level ($p > .1$ in all cases). This was also the case for individual control data, whether information was entered as cumulative or raw scores.

IH (lower panel). IH's cumulative information scores were entered in an ANCOVA parallel to that above, except that actual dates of events were entered as the covariate and the cues had six levels (a, b, c, d, e, f). In addition, event 13 was omitted from analysis as an outlier, since IH was unable to remember any information for this event. Removal of this item should not have unduly affected the results, since it occurred in 1988, so falling midway between the theoretically crucial time periods of very remote and very recent events.

As can be seen in Figure 5 and Table 2, IH gave more information with increasing provision of cues. Like controls, he showed a main effect of cue type, $F(5, 70) = 2.58$, $p < .05$. Unlike controls, IH also showed an effect of the covariate date of event, $F(1, 14) = 4.6$, $p < .05$. Overall, there is a modest recency effect, with more information generated for the later events. Most importantly, this effect was modulated by a significant interaction between date of event and cue level, $F(5, 70) = 2.72$, $p < .05$.

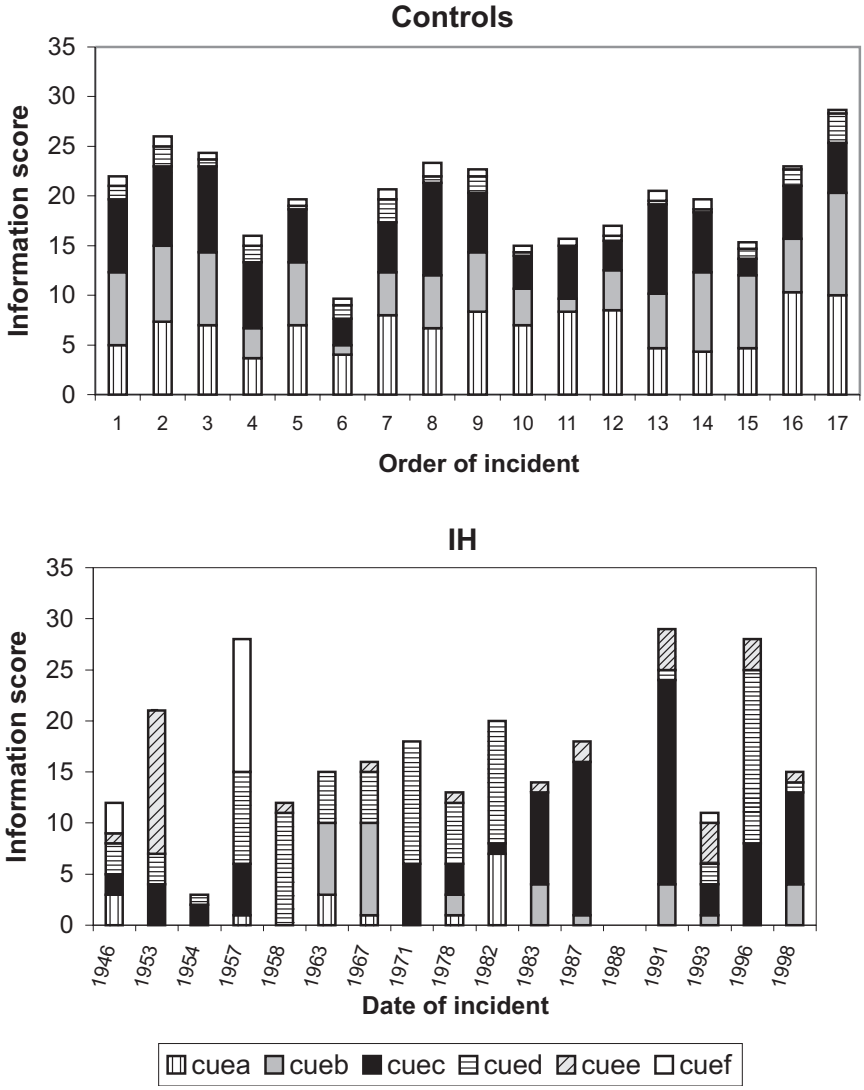

Figure 5. *Information scores for the control group (upper panel) and for IH (lower panel) in the Cued Autobiographical Memory Test. The cumulative scores for each level of cueing specificity (a–f) are shown for each incident. Actual dates of incidents are shown on the x-axis for IH whereas for the control group, incidents are arranged in order from the earliest to the latest from 1–17, since individual dates of incidents vary across the three control subjects.*

This interaction was explored by examining correlations between date of event and cumulative information scores for each level of cueing separately: There were significant Pearson correlations for the intermediate levels of cueing, c and d: $r(15) = .578$, $p = .019$ and $r(15) = .543$, $p = .03$, respectively. These correlations are displayed in a scatter plot in Figure 6.

In contrast, there were no significant correlations for the most general cue levels a and b. This is due to the fact that IH was usually able to generate very little information to these general cues, so his recall curve was flat and near to floor. Nor were there significant correlations between cumulative information score and date of event for the most specific levels of cueing, e and f: $r(15) = .480$, $p > .05$

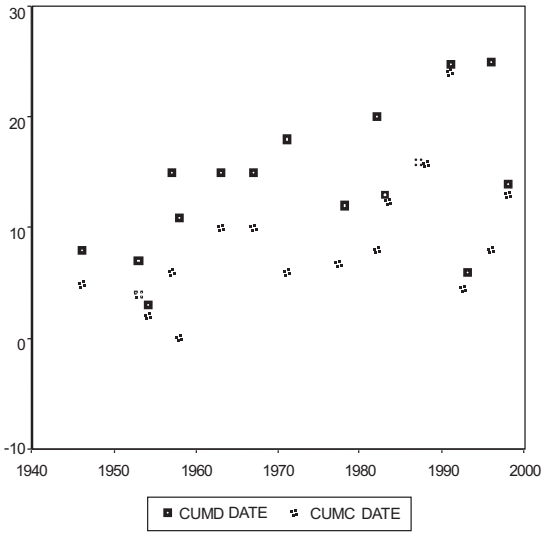

Figure 6. *Scatterplot showing the positive correlation between the date of the event and IH's cumulative information score for cue levels d (CUMD-DATE) and e (CUMC-DATE).*

and $r(15) = .298$, $p > .2$, respectively. Indeed, there was a nonsignificant trend whereby IH tended to generate more additional information for the earlier events in response to cues e and f, thereby cancelling out the recency advantage that was apparent for the intermediate levels of cueing. In other words, the level of cueing required to reach the total score changed across time-periods: IH retrieved most information at cue level c and d for more recent events, while cue levels e and f made a greater contribution for earlier events.

Finally, ANCOVA analyses were carried out for each individual control subject, to ensure that none of the subjects showed the same pattern as IH when their data were treated separately. This confirmed that no control subject showed either a main effect of date of event, or an interaction between date of event and level of cueing.

Ratings

In order to check that the results were not an artefact of our scoring method, we also analysed the rating scores on a scale of 0–3, as described above. A rating was given for the material generated in response to each level of cueing for each incident. We calculated the maximum score for each incident, and also a weighted maximum. The weighted score was the maximum score multiplied by a constant related to the specificity of cueing required: Thus a score achieved at the most general level of cueing, a, was multiplied by 6, while a score achieved at the most specific level, f, was multiplied by 1.

Control subjects. Maximum scores, regardless of level of cueing, are shown for controls and IH in Figure 7 (upper panel), with weighted maximum scores for controls and IH in the lower panel. For controls, there was essentially a flat function with no correlation between rating and date of event: maximum score: $r(50) = .011$, $p > .9$; weighted maximum score, $r(50) = .055$, $p > .7$. Controls were near ceiling for unweighted scores, with maximum scores of 2.5 to 3 for every incident.

IH. The upper panel of Figure 7 shows that IH's maximum scores were within the control range for many of the incidents. Maximum scores did not increase as a function of recency as shown by the lack of correlation between date and maximum score for IH, $r(16) = -.135$, $p > .6$. However, as can be seen from the lower panel of Figure 7, IH's weighted scores were considerably lower than the control means for most events. This shows that, although IH did eventually produce good descriptions of episodes for many incidents, he required more specific cues to do so. This finding did not vary across time-periods, and there was no significant correlation between date of event and IH's weighted scores, $r(16) = .293$, $p > .2$. There were no significant correlations between rating scores and date of event, but a marginal effect at cue c, $r(16) = 0.439$, $p = .089$, such that recent events scored more highly at this cue level.

Discussion

The first and most important finding was that IH was able to produce as many pieces of information (first scoring method) or incidents specific in time and place (second scoring method) as controls (with

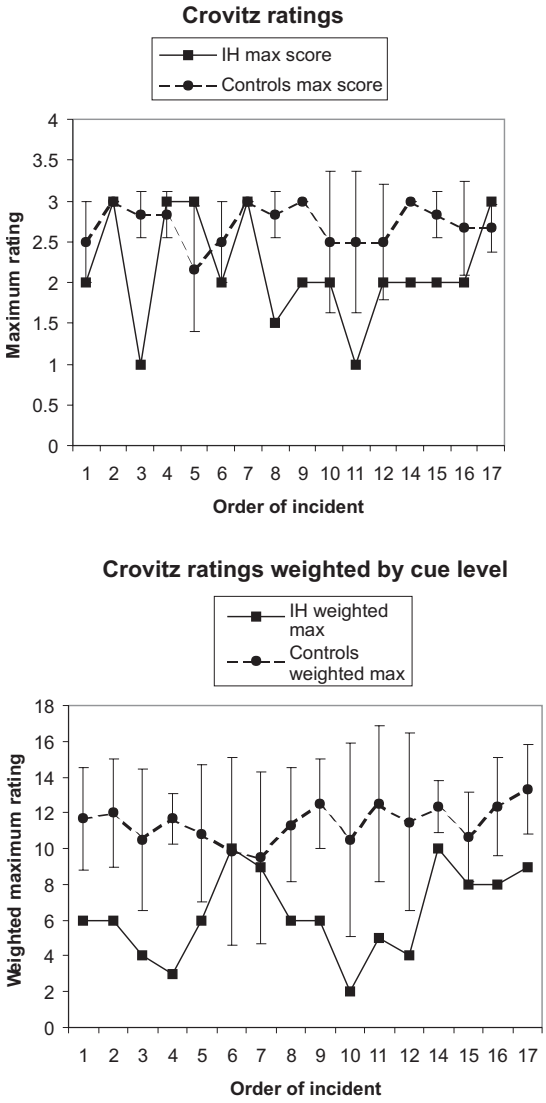

Figure 7. *Crovitz scores for IH and control group for the Cued Autobiographical Memory Test. The upper panel shows the maximum scores at any level of cueing for IH and the control average. The lower shows the scores for IH and control group when weighted according to the level of cueing at which the maximum score was attained. Error bars show ±1 SD.*

the exception of the earliest two data-points using the first scoring method), but he required considerably more cueing to do so. This suggests that IH's primary impairment might be a consequence of his semantic deficits affecting the output or retrieval of autobiographical memories, rather than in the storage of autobiographical memories per se: This issue will be considered further in the General Discussion. Further analyses examined the effect of recency. Overall, there was no significant correlation between recency of event and total (cumulative) information score or Crovitz rating score. However, there was an interaction between date of event and cue level for IH, which was absent for the control subjects. Correlation analyses revealed that this was because IH could give more information in response to the intermediate cues for the recent than for the remote events. This was consistent with our hypothesis that IH might have had intact memories for older events, but he was unable to retrieve and express these memories without additional cueing to overcome his semantic deficits. Cues at levels c and d were sufficient to generate detailed memories for more recent events, while the additional cues e and f were needed to bring the information scores for the older memories up to the same level.

Given this pattern of results, it is possible that the previous findings of a recency effect for semantic dementia patients in autobiographical memory tests might be the result of cues being employed in most procedures that are comparable with our intermediate levels c and d. At cue level c, we were asking questions such as "Tell me something that happened in your childhood to do with sport" or "Tell me about something that happened when you were in your forties to do with a family holiday." This is quite similar to the level of question in the Crovitz-Galton procedure as used by Graham and Hodges (1997), in which the patient was asked to generate an incident from a certain time period in response to a cue word such as *hospital* or *family*. Similarly, in the Autobiographical Memory Interview, patients are asked to recall an incident—for example, from high school—and are prompted with words such as "Involving a teacher? Involving a friend?" Again, this is similar to our intermediate cue levels c and d. Perhaps if additional, more specific cues had been supplied in the earlier studies, the semantic dementia patients would have been able to give more information for the remote events, so reducing the recency advantage.

The present findings indicate that, while remote events are not lost, they are certainly more difficult to access and/or express than are more recent events. However, examination of the data plotted in Figures 4 and 5 did not give any hint of a step-like function: IH's total scores for events from the last 2 years, 1996 and 1998 (total scores of 28 and 15, respectively), were very similar to those for the previous two events in 1991 and 1993 (total scores of 29 and 11, respectively). On the contrary, they tend to suggest a gradual improvement with recency, going back 20 years or more. However, there were only a very few incidents in the critical time period covering the most recent few years. Consequently, we needed to test IH's memory for very recent events in more detail in order to address this question. This was the aim of Part 2 of the cued autobiographical memory test.

CUED AUTOBIOGRAPHICAL MEMORY TEST: PART 2

Method

In order to elicit further information about IH's memory for events within the last few years, a second interview was constructed. One problem with comparing memories from different events is that they naturally vary in their salience and emotional content, so that some are inherently more memorable than others. To minimise this variability, we asked IH about four events or occasions that reoccur every year, so that we could compare like with like as much as possible. These events were (1) a family Christmas, (2) a visit to the dentist, (3) FA cup football match, and (4) US Masters golf championship. These were targeted to correspond to IH's interests. First, he had been close to his family and he had enjoyed holiday times with them. Second, he was very particular about his dental care and had talked about dentists in informal conversation. Third, he was a keen armchair sportsman, with football and golf being among his favourite sports. To capitalise on these interests, we asked IH to tell us about these four events for the current year and for each of the previous 3 years.

As in the first experiment, we contrasted IH's responses to general and specific cues. General cues were simply of the form: "Can you tell me about a family Christmas/visit to the dentist/FA Cup final/US golf Masters in any of the last 3 or 4 years?" IH was allowed to give as much information as he could before specific cues were provided. Three types of specific cue were given. First he was given an additional question "Can you tell me where you were and who you were with that Christmas?" "Can you tell me what you had done at the dentist that time?" "Can you tell me where you watched that match/tournament and who with?". Second, he was prompted to generate a memory for a specific year in the last 3 years if he had not already given a date. Third, IH was given a three-choice recognition question in written and spoken form. This gave a correct answer and two plausible foils to the following questions: Where he had spent Christmas for the year in question; what treatment he had received at the dentist in the year in question; which team/golfer had won the FA Cup/US Masters in the year in question. The correct answers and plausible distracters were ascertained through interview with the family member for the first two events, and by reference to sports reference books.

In total we recorded responses for 14 separate incidents, (4 football and 4 golf events, 3 dentist visits and 3 Christmases) spanning a period of just over 3 years, from April 1995 to a few months before testing in August 1998. Graham and Hodges (1997) suggested that the cut-off for preserved memory in semantic dementia lies approximately 18 months to 2 years before testing. The time span of our recent events tests allowed us to examine IH's memories before and after this putative cut-off.

Procedure

IH was tested in two interviews of several hours, separated by 2 weeks in August 1998. He was asked questions for each of the 4 years for Christmas, dentist, football, and golf events respectively. One incident (visit to the dentist in 1995) was accidentally omitted. The interviews were recorded onto videotape and subsequently transcribed.

Control subjects

Four men of a similar age to IH (range 61–70) were also tested on the recent events interview. The control subjects were all married with grown-up children and were keen sports viewers. Two of the controls also took part in Experiment 1 above, and two were recruited anew on the basis of their sporting interests. None of the controls considered themselves to have any memory difficulties. The questions given to controls were the same as those for IH, with the exception that they were not given multiple-choice questions for the Christmas and dentist events. This was because we had not interviewed family members to obtain the correct answers and plausible distracters. We assumed that subjects with no significant memory impairments would not need multiple-choice questions to retrieve the relevant information. If control subjects reported that they had not visited the dentist at all in a given year, we asked them equivalent questions concerning a visit to a doctor instead.

Controls were tested in a single interview lasting just over 1 hour in May 1999. The interviews were recorded onto audiotape and later transcribed.

Results

As for the previous experiment, subjects' responses were scored in terms of the number of pieces of information given for each event at each level of cueing. Scores were assigned by 2 experimenters independently and any discrepancies resolved by discussion.

Controls. The mean number of pieces of information given by the control group for each event is plotted in the upper panel of Figure 8. Scores are split into information given in response to:

1. General cues: e.g., "Can you tell me about a family Christmas within the last 3 years?"
2. Specific cues: a specific year plus, e.g., "Can you tell me who you were with and where you were that Christmas?", any prompts for dates, plus multiple-choice questions for the sports events.

These data were then analysed by comparing the scores on either side of a temporal cut-off using independent sample two-tailed *t*-tests. Two potential cut-off points were investigated—1 year and 2 years prior to testing. For the 2-year cut-off, there was a marginal increase in the mean number of pieces of information given for the 10 events within the last 2 years compared to the 5 earlier events, both in response to general cues only, $t(13) = 1.89$, $p = .08$, and the total amount of information, when specific cues are included, $t(13) = 1.8$, $p = .09$. The effect was more pronounced for the 1-year cut-off. Control subjects gave significantly more information for the six events 1 year prior to testing than for the nine earlier events, at least for the general cues. On average, controls were able to give 4.9 and 2.8 pieces of information to general cues for events within the last year and before the last year, respectively, $t(13) = 3.77$, $p < .01$. Specific cues elicited equal amounts of additional information for events within and before the 1-year cut-off, such that the total information score for events within the last year remained greater than that for earlier events (means of 6.9 and 5.2 respectively), $t(13) = 2.8$, $p < .05$. In summary, the control subjects were able to give more information for the most recent events compared to earlier events even within a relatively short time span of just over 3 years, particularly in response to general cues for events within the last year compared with the previous 2 years. This suggests that there may be a step-like function in the ease of access of autobiographical information for normal subjects. Examination of these data in Figure 8 shows that any such effect is very modest. Nevertheless, it is important to note this tendency for better memory for events within the last year within the control population, as it provides the appropriate context for interpreting the pattern of retrieval for patients.

IH. Information scores were computed for IH in the same way as for the control subjects, the only difference being that IH was given multiple-choice questions for the family Christmas and dentist events as well as for the sports events. IH's results are plotted in Figure 8 (lower panel). This shows that for many events IH was able to give as much

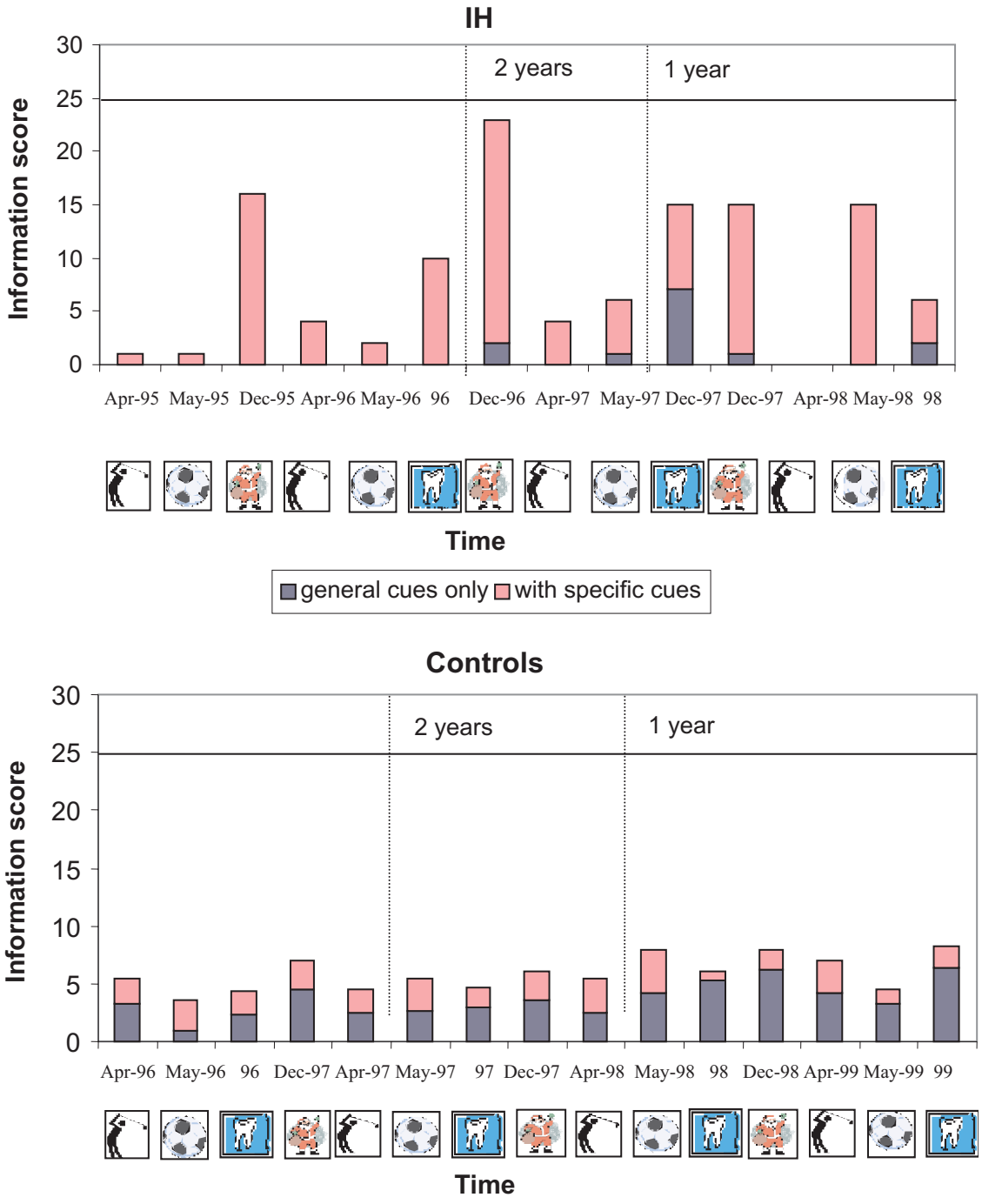

Figure 8. *Information scores for IH and control group for the second part of the Cued Autobiographical Memory Test, probing events over the last three years. The upper and lower panels show the scores, both with general and specific cues, for controls (upper panel) and IH (lower panel) respectively. The pictures along the x-axis indicate the nature of the episode, (FA Cup final, visit to dentist, US golf Masters, family Christmas).*

information, if not more, than were controls. However, whereas control subjects gave most information in response to general cues, with relatively little additional information elicited by specific cues, the reverse is true for IH: He produced very little information to general cues in most cases, but he produced many more pieces of information when more specific cues were provided.

We compared IH's information scores for events before and after the cut-off points of 1 and 2 years. Numerically, IH shows the same pattern as the control subjects, with more information retrieved for the most recent vs. the earlier events (see Table 3). However, t-tests revealed no significant differences between the time periods when the cut-off was placed at 1 year: general cues only, $t(12) = 1.258$, $p > .1$; including specific cues, $t(12) < 1$. With the cut-off at 2 years before testing, there was a very small increase in the information given to general cues only, $t(12) = 1.976$, $p = .089$, but no effect when specific cues were included, $t(12) < 1$. IH's pattern of performance was similar to that of controls in that his scores in response to general cues tended to increase as a function of recency, whereas his scores in response to specific cues did not, consistent with the view that the most recent memories were somewhat more easily accessed. Overall, there was no evidence that IH's pattern of performance differed from that of the controls or that he showed a step-like preservation of memories for the past 1 or 2 years.

Table 3. *Information scores for IH and controls for recent events*

	IH		*Controls (mean)*	
	Before	*After*	*Before*	*After*
	1 year cut-off			
General	0.33	2	2.8	4.9**
Specific	7.1	8.2	2.04	2.35
Total	7.43	10.2	4.84	7.25*
	2 year cut-off			
General	0	1.6†	2.7	4.1†
Specific	5.67	8.87	2.2	2.25
Total	5.67	10.47	4.9	6.35†

†$p < .1$, *$p < .05$, **$p < .01$.

Discussion

As in the previous study, but perhaps even more markedly, the present experiment indicated, first, that IH was able to produce autobiographical memories at least as well as controls, but he required considerably more cueing to do so. Second, there was no evidence of a step function in his retrieval of memories from the last 3 years, particularly when account was taken of the recency effect in controls. Taken together with the findings in the previous study, these results suggested that the recency effect in IH extended back gradually over several years, and that it was evident only at intermediate levels of cueing.

GENERAL DISCUSSION

This study was designed to test the hypothesis that the remote autobiographical memory in semantic dementia may have been underestimated in previous studies due to the lexical semantic deficits of the patients. We suggested that cueing might help patients retrieve and express older memories, so cancelling out the apparent recency advantage. The results of our two cued autobiographical memory interviews support this hypothesis. Our semantic dementia patient, IH, showed the expected recency effect on the two components of the AMI, a standard test of autobiographical memory, although not on a news events test. A different picture emerged when IH was provided with a hierarchy of increasingly specific cues to test his autobiographical memory for salient events across his lifespan.

The main results of autobiographical cueing were as follows.

1. *When detailed cues were provided, IH could retrieve autobiographical memories* and provide comparable detail to that given by healthy subjects, even though his descriptions were slow and laborious because of his language difficulties. This is consistent with the view that older memories are not entirely lost as a result of the left temporal lobe damage in semantic dementia, but rather that they are more difficult to retrieve and/or express. In brief, the patient's deficit was predominantly

semantic rather than implicating the storage of autobiographical memories per se.

2. *There was a significant interaction between age of event and the level of cueing required.* The total amount and specificity of information recalled was the same for older and recent events, but IH required significantly more cueing to achieve the same level of performance for the older memories. One account of this interaction is that the words and concepts relevant to the most recent events are supported by their current relevance to everyday life and experience, which "invest" them with meaning (Snowden et al., 1996, 1999). These relatively preserved words and concepts permit comprehension of the question, retrieval of the event, and output of the description for recent autobiographical memories. The impaired conceptual representations of words that are *not* relevant to current experience mean that all three aspects (comprehension, retrieval, and output) are more difficult for the older events; thus, these older memories have more scope to benefit from the provision of explicit lexical cues within the cued autobiographical interview. It might be argued that, if older memories were partially degraded (as suggested perhaps by the first two data-points in the lower panel of Figure 4, although not in Figure 7), this would be one reason why more extensive cueing is needed to retrieve them, but IH's ability to retrieve information to cues across *all* the data-points refutes any strong claim that the older memories have simply been lost.

3. *There was a recency effect only for intermediate level cues.* IH showed a correlation between the date of an event and the amount of information retrieved for cues only at the middle level of our hierarchy. When cueing was more general, he was essentially at floor. When cueing was more specific, there were nonsignificant trends whereby IH retrieved more additional information from the earlier time periods. We have suggested that the questions asked in standard tests such as the AMI or modified Crovitz are similar to the intermediate level of cueing, and that this may explain why recency effects have been found in semantic dementia patients in earlier studies of autobiographical memory (e.g., Graham & Hodges, 1997; Snowden et al., 1996).

4. *IH did not show a step-like improvement in memory for events within the last 1 or 2 years.* In the second interview we specifically tested memory for comparable events over the last 4 or 5 years. IH showed a trend towards better memory for the most recent events, but this was nonsignificant and followed the same pattern as was obtained in controls.

The locus of the cueing effect: Comprehension, output and retrieval

The hypothesis we set out in the introduction was that semantic dementia patients are likely to have difficulty understanding the questions asked in an autobiographical memory interview, and in activating and selecting the semantic information required to express their memories. We suggested that provision of lexical cues might partially overcome this problem. Our results are consistent with this hypothesis. The findings from Westmacott et al.'s (2001) patient, EL, were also consistent with the view that memory retrieval and output problems in semantic dementia are largely the result of semantic impairment rather than a more general problem in strategic recall. EL had great difficulty understanding verbal cues and in describing episodes in words, yet he was able to recognise and remember events portrayed in family photographs from throughout his life, including early childhood. Like IH, EL's apparent difficulty in remembering remote autobiographical information was dramatically alleviated when the burden on verbal comprehension and production was reduced.

Although it is plausible that difficulties with understanding the questions and finding words to express incidents would contribute to IH's poor performance on autobiographical memory tests, it is perhaps less obvious why increasingly specific lexical cues should have helped to alleviate this problem. Given that the more specific cues often contained lower-frequency words, it seems unlikely that he would have found them easier to understand. For example, if IH had difficulty understanding the question "Can you tell me about something that happened when you were a child?," he would be unlikely to fare any better on the more specific question "Can you tell me tell me about

when you played rugby at school?". Our first point here is that the cues were not presented in isolation from each other, but in sequence, so that it may have been the cumulative effect of both general and specific cues that aided performance. Thus the overlapping information retrieved from partially degraded semantic representations for several words (*child, school, sport, rugby, play, position*) may eventually have summated to a point where the overall question was understood. The multiple cues also increased the chance that a word or phrase would access a small pocket of relatively preserved information. The likelihood of this happening was tied to the personal relevance of the word, rather than its frequency. A clear example of this occurred when the experimenter asked IH about something that happened in his teenage years concerning career or occupation. IH was unable to give any information, but then suddenly saw the word RAF (the next cue) printed on the experimenter's sheet, a word that he instantly understood, and which provided the basis for a detailed account ("Oooh,, RAF! Oh I came up with, in the North and West, and they came up outside London, 18 months, oh, it was superb, marvellous . . . 1953, RAF, with regards to myself . . ."). Both the cumulative effect of multiple cues and the increased likelihood of accessing small areas of preserved information highlight ways in which the difficult task of activating the right part of a severely degraded semantic space can be ameliorated. Lambon Ralph and Howard (2000) report a similar effect, in which related picture cues were able to facilitate word comprehension for a semantic dementia patient. This effect was modelled in a connectionist network, in which the mapping between pictures and concepts was more systematic than that between words and concepts. In the current study, we did not employ pictures as cues, but we suggest that the comprehension advantage for multiple personally relevant cue words could "prime" the correct area of semantic space in a similar way. A second point here is that IH's word-finding difficulties were more severe than his comprehension deficit, as is the case with many semantic dementia patients, and consequently the limiting factor in recounting an episode was often the ability to produce the appropriate words, rather than comprehension per se. The provision of specific lexical items could often overcome this hurdle so that IH could get started on a story (as in the case of the RAF example and the rugby incident quoted earlier, in which IH was able to tell a story about scoring a try in the final minute of a game, once his search for the word *try* had been solved by the experimenter.)

It is also possible that lexical cues had their effect not only on the comprehension of questions and expression of memories, but on the retrieval of the memories themselves. First, Nadel and Moscovitch (1997) proposed that semantic dementia patients may have deficient "frontal processes," which leads to problems with the strategic retrieval of episodic memories. This is a plausible possibility, given that patients with frontal lobe lesions have been shown to have difficulties in retrieving specific autobiographical memories (Baddeley & Wilson, 1986; Kopelman et al., 1999). However, there was only very minor atrophy frontally on IH's MRI and he showed excellent performance on card sorting and Raven's matrices (see Table 1). Nestor et al. (2002) have also provided evidence suggesting that impaired strategic retrieval is unlikely to explain the autobiographical memory deficit in semantic dementia. Second, semantic and retrieval factors may not be independent. IH (like all semantic dementia patients by definition) had problems with the comprehension and output of meaningful language: it seems feasible that this would have major implications for performance in other cognitive domains. Semantically impoverished words/concepts may make inefficient cues for retrieving specific episodes from the database of autobiographical memories. Evidence consistent with this proposal comes from a study of normal subjects, who were able to retrieve significantly more specific memories in response to cue words that were high rather than low in imageability (Williams, Healy, & Ellis, 1999). Further analysis showed that recall improved as a function of both visual imageability and ease of predication (i.e., the number of statements that could easily be generated in response to a word: cf. Jones, 1985). The authors concluded that "semantically rich" words facilitate the cyclical search processes involved in retrieving specific

information from a hierarchically organised database of autobiographical knowledge. We know that for semantic dementia patients the richness of all concepts is reduced due to the progressive loss of semantic properties (Hodges, Graham, & Patterson, 1995; Tyler & Moss, 1998). Therefore, the effectiveness of all such concepts as retrieval cues will be reduced. As we have already suggested, those concepts that are relevant to the patient's life may be the ones that remain relatively intact, so that these may be the most efficient recall cues. As already mentioned, it was very noticeable how IH would hesitate in giving a response until a specific cue appeared to get him going (as in the RAF and rugby examples above).

One possible interpretation of the present findings is within a "levels of meaning" conception of semantic representation (Funnell, 2001; Snowden & Neary, 2002). Funnell has suggested that there is a continuum of representation from specific and context-bound to abstract and context-independent knowledge. The "lower" levels of representation are at least partially in the form of scripts for specific and general events. On the assumption that the erosion of semantic knowledge in semantic dementia primarily affects the higher level of conceptual knowledge, patients will be left reliant on the context-dependent aspects of semantic knowledge that are closely bound up with their own personal event knowledge. The specific lexical cues used in our autobiographical memory interview may have been more productive than the more generic higher-level cues because they mapped much better onto semantic representations at the specific and general event knowledge levels.

Our present findings beg the question of where IH's autobiographical memories are stored, given that he has such extensive atrophy of the left temporal lobe with the expected effects on all aspects of semantic memory. Although neuroimaging studies to date have produced conflicting findings concerning the storage and retrieval of remote memories (Fink, Markowitsch, Reinkemeir, Bruckbauer, Kessler, & Heiss, 1996; Maguire & Mummery, 1999; Ryan et al., in press), lesion studies have indicated disproportionate damage to autobiographical memory recall following bilateral frontal (Baddeley & Wilson, 1986; Della Sala et al., 1993; Kopelman et al., 1999), or right temporal lobe pathology (Kopelman et al., 1999; O'Connor, Butters, Miliotis, Eslinger, & Cermak, 1992; Rubin & Greenberg, 1998), and the consensus is that autobiographical memories are supported by widespread circuits within these brain regions (Kapur, 1999; Kopelman, 2000a, 2002). These structures were relatively preserved in IH and, consequently, it seems reasonable to hypothesise that they contributed to the storage and retrieval of his remote memories. Moreover, numerous studies have demonstrated that the right hemisphere supports a range of semantic functions, although opinions vary as to their nature: the right hemisphere may be limited to frequent, concrete words, or support coarse, diffuse processing and/or be specialised for pictorial rather than verbal semantics (see Chiarello, 1991, for a review). To add to this list of possibilities, we speculate that the right hemisphere might also be better able to support representation of meanings at the more context-bound end of the continuum proposed on the "levels of meaning" account, rather than the most generalised context-independent conceptual representations. IH's intact right hemisphere may also more generally account for his preserved abilities as a good raconteur—when cueing was sufficient for him to recollect an incident, it was almost always recounted in a (slow and laborious but) well-structured way, with interesting details, appropriate filling in of background details, and often with great feeling and humour. Data from patients with right hemisphere damage have demonstrated the importance of the right-hemisphere in inference and social cognition (Brownell & Martino, 1998) and the production of narrative (Gardner, Brownell, Wapner, & Michelow, 1983). In these respects, IH appears to have differed from patient AM with *bilateral* temporal lobe damage (Graham et al., in press), for whom cueing with family photographs did not facilitate retrieval of autobiographical memories.

In conclusion, the semantic deficit in semantic dementia may impair the comprehension of cues, the retrieval of autobiographical memories, and the ability to express remembered events. To the extent that concepts relevant to recent life are "invested

with meaning" (Snowden et al., 1996, 1999) and are therefore relatively preserved, this will increase semantic dementia patients' performance on recent events in tests of autobiographical recall. These concepts and contextual cues may be less relevant to the retrieval of ("more semantic") public information—hence, it is more difficult to obtain a recency effect on tests of famous news events or famous names. When increasingly specific lexical cues were provided in our cued autobiographical test, this recency advantage was eventually cancelled out such that the patient retrieved autobiographical memories across all earlier time-periods. We have suggested (1) that these cues facilitated both the verbal expression and retrieval of autobiographical memories, (2) that IH's relatively intact autobiographical memory may have reflected relatively unimpaired right hemisphere functioning, and (3) that his primary deficit was indeed lexical–semantic rather than in the storage of autobiographical memories per se.

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APPENDIX A

Set of cues for subset of three incidents in the Cued Autobiographical Memory Test: Part 1

1. Father dying in 1957
a. Can you tell me about something that happened in your early 20s?
b. Can you tell me something that happened in your early 20s to do with hospital?
c. Can you tell me something about a death in your family when you were in your early 20s?
d. Can you tell me about your father dying?
e. Did your father die of heart disease, kidney disease or asthma?
f. What year did your father die?

2. Stockmarket crash in 1987
a. Can you tell me about something that happened in your early 50s?
b. Can you tell me about something that happened in your early 50s to do with your work?
c. Can you tell me about the stockmarket crash when you were in your 50s?
d. Can you tell me about where you were working during the stockmarket crash?
e. Were you working at X, Y*, or working for yourself at this time?
f. What year was the stockmarket crash?

3. FA Cup final in 1998
a. Can you tell me about something that happened when you were in your 60s?
b. Can you tell me something that happened in to do with sport in your 60s?
c. Can you tell me about the football FA Cup final this year?
d. Can you tell me about where you watched the football FA Cup final this year?
e. Who won the football FA Cup final this year—Newcastle, Arsenal, or Everton?
f. When did the football FA Cup final take place?

Multiple choice options are underlined.
*X and Y are two financial companies.