Preserved Recognition in a Case of Developmental Amnesia: Implications for the Acquisition of Semantic Memory?

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Abstract

■ We report the performance on recognition memory tests of Jon, who, despite amnesia from early childhood, has developed normal levels of performance on tests of intelligence, language, and general knowledge. Despite impaired recall, he performed within the normal range on each of six recognition tests, but he appears to lack the recollective phenomenological experience normally associated with episodic memory. His recall of previously unfamiliar newsreel events was impaired, but gained substantially from repetition over a 2-day period. Our results are consistent with the hypothesis that the recollective process of episodic memory is not necessary either for recognition or for the acquisition of semantic knowledge. ■

INTRODUCTION

In the last few decades, there has been extensive research into the cognitive neuropsychology of the amnesic syndrome, ranging from Milner's (1966) early research on patient HM, through the attempts to relate the functional deficits of amnesic patients to laboratory studies of normal subjects (Squire, Knowlton, & Musen, 1993; Baddeley & Warrington, 1970), up to the present situation in which it is widely accepted that data from study of the amnesic syndrome make a crucial contribution to our current concepts of normal human memory (Schacter & Tulving, 1994). While there have been numerous attempts to argue for different types of amnesia usually related to differential lesions (Parkin, Leng, & Hunkin, 1990; Huppert & Piercy, 1979), such subdivisions have proved difficult to sustain, leading to a somewhat negative, though by no means universal consensus of a unitary amnesic syndrome (Squire, 1992; Baddeley, 1997).

This modal view distinguishes between explicit or declarative memory that is grossly impaired in amnesia, and a range of implicit, procedural, or nondeclarative memory systems that are intact (Baddeley, 1997; Squire, 1992). These implicit memory systems have in common the fact that they operate in the absence of conscious recollection.

Explicit or declarative memory can itself be split into two components: episodic memory, which represents the capacity to store and recollect experienced events; and semantic memory, a system that stores and retrieves knowledge about the world (Tulving, 1972). The term episodic memory is used generally to refer to the capacity to recollect past experience, either by recalling the event, or in the case of recognition, by recollecting information associated with the learning experience (Tulving, 1972). This phenomenological aspect of episodic memory is essential to Tulving's use of the term, although others use the term somewhat more broadly. There has in recent years been considerable interest in the phenomenology of recognition, with considerable evidence that subjects are successfully able to categorize items they have recognized on the basis of whether they have been remembered with associated recollective experience, or whether subjects simply "know" that the item had previously been presented (Gardiner & Java, 1993).

Semantic memory is assumed to reflect accumulated world knowledge such as the meaning of the word "fish," the color and taste of a banana, the number of yards in a mile, or the normal procedure for eating in a restaurant. While amnesic patients usually retain semantic knowledge acquired before the onset of amnesia, they typically have great difficulty in adding further information to their semantic memory systems, for example, amnesic patients would generally be unable to provide the names of current political figures such as the U.S. President, and would be unaware of recent world events and of the meaning of newly coined words (Squire et al., 1993). The association of impaired episodic memory with the failure to update semantic memory is consistent with the view that semantic memory re-

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flects the residue of many episodes (Baddeley, 1997; Squire, 1992), although this view is not universally held (Mishkin, Vargha-Khadem, & Gadian, 1998; Tulving, 1972; Tulving & Markovitch, 1998).

Although this overall view has, for many years, been able to account for the bulk of evidence, it has recently been challenged by the description of what appears to be a new amnesic syndrome. The patients concerned appear to have developed amnesia to a greater or lesser degree at, or within, a few years of birth, a situation which should, according to the modal view, have led to grossly impaired semantic memory. Nevertheless, three such cases reported by Vargha-Khadem et al. (1997) have demonstrated an apparently normal acquisition of language, together with a remarkably well developed knowledge of the world. The implication of such cases for the concept of semantic memory is discussed elsewhere (Mishkin et al., 1998; Squire & Zola, 1998; Tulving & Markovitch, 1998); the purpose of the present study is to investigate further the nature of the memory deficit, and in particular, to provide a more robust test of the suggestion by Vargha-Khadem et al. that this type of amnesia may be associated with preserved recognition memory despite clear evidence of impaired recall. Such a dissociation is not typical of the amnesic syndrome: Patients not only fail to successfully recollect prior experiences, but they also fail to distinguish between novel words, pictures or events, and items that have already been presented (Squire et al., 1993).

We begin by recapitulating the case of Jon, one of the three described by Vargha-Khadem et al., illustrating the evidence for his amnesia, together with the comparative preservation of his semantic memory. This is then followed by a summary of his neuropathology as determined by quantitative magnetic resonance techniques. We then go on to a brief account of earlier claims of preserved recognition in patients who have acquired their amnesic deficit as a result of brain injury during adulthood. We discuss some of the methodological problems facing any attempt to compare recall and recognition, before describing a study in which we compare Jon's recall and recognition for both visual and verbal material. In order to study the generality of our findings, we then compare Jon's performance to that of normal control subjects across several other recognition paradigms. We then discuss the implications of our results for the distinction between recall and recognition memory, and for the development of semantic memory.

The tests used comprised both standardized measures for which appropriate norms are available, and less widely used experimental tests. For the latter, the question arises as to the appropriate control comparison. When tested at age 19, Jon showed a slightly unusual WAIS-R intelligence profile, with his performance IQ (120) being somewhat greater than his verbal IQ (108). Finding age- and education-matched subjects with a similar profile, who were also able to absent themselves from work for the several days necessary to complete the full test battery, proved difficult. We were, however, able to locate two such control subjects. Their results were used, together with results from the somewhat larger but less well matched groups from the published literature, as a baseline for interpreting Jon's performance.

Case Description

Jon, who is now 23, was born prematurely at 26 weeks of gestation, weighing less than 1 kg and suffering from breathing problems (Gadian et al., 2000). For prolonged periods during his first six weeks of life, he suffered from severe apnea, requiring intubation and positive pressure ventilation. He subsequently showed steady improvement and normal development. At 3 years 10 months, he had an unconfirmed convulsive episode in association with cold and cough. His memory problems were first noted when he was about 5 years old, and have since continued to be prominent. More specifically, Jon's parents report that he has difficulty in reliably finding his way, tends to forget where objects and belongings are usually kept or where they have just been put, and makes many prospective memory errors, finding it difficult to keep even regularly scheduled appointments unless reminded. Jon also has difficulty remembering details of everyday activities such as conversations or television programs watched. The severity of the disability is such as to make it difficult for Jon to cope independently, or to succeed in finding and keeping a job.

Table 1 shows the performance of Jon and the two control subjects, Andrew and Max, on intelligence, scholastic, and language performance tests, all carried out between the ages of 19 and 22. Jon has above-average intelligence with a full-scale IQ of 114, with subtest scores ranging from scaled scores of 10 (the normal average) on information, to 16 (two standard deviations above the mean) on block design. His number skills as measured on the Wechsler Objective Numerical Dimensions (WOND) test are above average, while his reading performance is within the normal range for basic reading (55th percentile) and comprehension (42nd percentile) coupled with poor spelling (14th percentile). Jon's language is also within the normal range as measured by the Token Test, which requires the following of instructions of increasing grammatical complexity, and his semantic judgements appear to be normal, as measured by the Pyramids and Palm Trees Test, a test of semantic access from words and pictures (Howard & Patterson, 1992). Jon's vocabulary development is also within the normal range, with the WAIS-R vocabulary subtest producing a scaled score of 14, while his comprehension subtest score was 11. Finally, his performance on the Spot the Word Test (Baddeley, Emslie,

Table 1. IQ, Academic Attainments and Language

Test	*Jon*		*Andrew*		*Max*	
WAIS-R	*Standard score*	*Range*	*Standard score*	*Range*	*Standard score*	*Range*
Full-scale IQ	114	High average	114	High average	101	Average
Verbal IQ	108	Average	107	Average	97	Average
Performance IQ	120	High	120	High	108	Average
Years of education	13		13		13	
Academic attainments	*Standard score*	*Percentile*	*Standard score*	*Percentile*	*Standard score*	*Percentile*
WOND						
Mathematics reasoning	103	58	118	88	118	88
Numerical operations	115	84	108	70	119	90
WORD						
Basic reading	102	55	108	70	102	55
Spelling	84	14	111	77	102	55
Reading comprehension	97	42	102	55	86	18
Language	*Raw score*	*Range*	*Raw score*	*Range*	*Raw score*	*Range*
Token Test	60/62	Normal	n/a[a]	n/a	56/62	Normal
Pyramids and Palm Trees	49/52	Normal	52/52	Normal	51/52	Normal
	Scaled score	*Range*	*Scaled score*	*Range*	*Scaled score*	*Range*
WAIS-R vocabulary	12	Average	12	Average	9	Average
WAIS-R comprehension	10	Average	12	Average	10	Average
Spot the Word	10	Average	11	Average	9	Average

[a]Not administered.

& Nimmo-Smith, 1993) was also within the normal range. This is a lexical decision task in which pairs of items are presented, one comprising a word and one a nonword; Jon's score of 47 out of 60 places him at the 50th percentile. In conclusion, apart from poor spelling, Jon has above-average intelligence and performs normally on scholastic and language tests, including eight different tests of semantic or language processing.

In 1991, Jon was tested on the Wisconsin Card Sorting Test, using the original Milner (1963) procedure. He obtained five categories, making a total of 25 errors of which 24 were perseverative. This indicates performance within the normal range. His category fluency tested at this time was also normal (20 animal names and 14 fruit types). In 1997, he was tested on the FAS initial letter fluency task, producing 50 words, which places him between the 70th and 80th percentile. In the same year, he was tested on the Behavioural Assessment of the Dysexecutive Syndrome (BADS) (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), which comprises a number of subtests sensitive to different aspects of executive processing. He scored 21/24, an entirely satisfactory performance. He was noted to be thinking ahead, planning for the future, but easily distracted, and with some trouble with decision-making. In general, Jon's executive capacities appear to be within the normal range.

Table 2 shows the performance of Jon, Andrew, and Max on standardized memory tests. On the recently developed Extended Rivermead Behavioural Memory Test (Wilson et al., 1999), his profile score of 10 indicates a level of performance that is well within the impaired range (0–18). Jon's visual memory, as indicated by delayed recall of the complex Rey Figure, was also dramatically impaired with no subsequent scoreable reproduction.

The Children's Auditory Verbal Learning Test-2 (with norms ranging from 6 to 18 years) involves presenting a sequence of 16 words five times, after which a second list is presented and tested (Delis, Kramer, Kaplan, & Ober, 1987). The initial list is then presented again and tested for recall and finally recognition. Jon does well on

Table 2. Memory Performance

Test	*Jon*		*Andrew*		*Max*	
Rivermead Behavioural Memory Test—Extended	*Profile score*	*Range*	*Profile score*	*Range*	*Profile score*	*Range*
	10	Impaired	33	Average	40	Good
CAVLT-2	*Standard score*	*Percentile*	*Standard score*	*Percentile*	*Standard score*	*Percentile*
Trial 1	108	70	98	45	125	95
Trial 5	77	6	117	87	108	70
Post interference	<60	<1	117	87	106	66
Delayed recall	63	1	118	88	118	88
	Raw score	*Percentile*	*Raw score*	*Percentile*	*Raw score*	*Percentile*
Recognition accuracy	29	<16	32	Normal	32	Normal
Intrusions	17	<16	0	Normal	0	Normal
Warrington Recognition Memory Test	*Raw score*	*Percentile*	*Raw score*	*Percentile*	*Raw score*	*Percentile*
Words	45	25	48	75	50	95
Faces	41	25	49	95	42	25

the initial test (68th percentile) relying heavily on recalling the last few words, the recency effect, which reflects short-term memory and hence, tends to be preserved in amnesia (Baddeley & Warrington, 1970). His subsequent scores of 8, 7, 8, and 10 show little evidence of learning, continuing to reflect a reliance on recency that is atypical in subjects with normal memory (Greene, Baddeley, & Hodges, 1996). Following the interfering list, a recall of four correct items with seven intrusions places Jon below the first percentile. In contrast, a final recognition score of 29 out of 32 places him just outside the normal cutoff of 30. A similar pattern of extremely poor word recall was shown when he was tested some 5 years earlier on a previous version of the test, whereas his recognition scores of 29/32 and 30/32 on two different occasions were both within the normal range for this older version of the test.

The Warrington Recognition Memory Test involves presenting 50 words and 50 faces, and in each case requiring subsequent two-alternative, forced-choice recognition (Warrington, 1984). In both cases, Jon scored at or above the 25th percentile, less well than one might expect from his general intelligence, but substantially better than suggested by his impaired performance on the various tests of recall described earlier. However, this level of performance should be treated with caution since Jon had performed this test on a number of occasions in the past, albeit separated by intervals of many months. Repetition might either have improved his performance, as a result of his becoming more familiar with the targets, or impaired it, since both targets and distractors would have some degree of familiarity. It is therefore clearly desirable to attempt to make a more direct assessment of recognition memory, and, if possible, to compare it with a comparable test of recall.

Neuropathological findings

As reported previously (Gadian et al., 2000; Vargha-Khadem et al., 1997), direct measurements performed on Jon's magnetic resonance scans revealed that the hippocampal volume in each hemisphere was approximately 50% less than the normal mean volume, a degree of atrophy that was clearly visible on the scans. This brain abnormality was also the only one visible, although quantitative MR techniques suggested the presence of more subtle pathology in other regions, including the putamen bilaterally, the ventral part of the thalamus, and the midbrain (Gadian et al., 2000). These additional abnormalities, like the bilateral hippocampal atrophy, are consistent with the known effects of hypoxia–ischemia, which is the presumed cause of the neuropathology in Jon. It should be noted that none of these MR techniques yielded evidence of bilateral pathology in the medial temporal tissue outside the hippocampus. In considering the unusual pattern of Jon's impaired and spared memory abilities, it is important to keep in mind this apparent selectivity of his ventral temporal damage, as it has raised the interesting possibility that just as his memory losses are attributable to the bilateral hippocampal atrophy, his preserved memory abilities are due at least in part to the preservation of the subjacent cortex in the parahippocampal region (Mishkin, Suzuki, Gadian, & Vargha-Khadem, 1997; Vargha-Khadem et al., 1997).

Neuropsychological Evidence for a Recall–Recognition Dissociation

The claim that recall and recognition are differentially affected by memory deficit has a long, if somewhat checkered history. It has, for example, been suggested, at least since Schonfield and Robertson (1966), that aging has a greater impact on recall than on recognition, and for a while, it was suggested that the classic amnesic syndrome might show such a dissociation (Huppert & Piercy, 1979). Unfortunately, such early studies are open to the objection that the recognition tasks used were simply less demanding than the recall, and it is now generally accepted that recognition memory is not preserved in most patients suffering from the amnesic syndrome (Aggleton & Brown, 1999; Reed & Squire, 1997).

A number of atypical cases have, however, been reported in which recognition does appear to have been preserved. These include patients with bilateral fornix damage (McMackin, Cockburn, Anslow, & Gaffan, 1995), patients with damage in the region of the mammillary bodies (Parkin & Hunkin, 1993; DuSoir, Kapur, Byrnes, McKinstry, & Hoare, 1990), patients who sustained anoxia (Volpe, Holtzman, & Hirst, 1986), cases with alcohol-induced Wernicke's encephalopathy (Parkin, Dunn, Lee, O'Hara, & Nussbaum, 1993), and a case with anterior communicating artery aneurysm (Hanley, Davies, Downes, & Mayes, 1994).

In a recent review of the amnesia literature, Aggleton and Brown (1999) and Aggleton and Shaw (1996) have argued for a preservation of recognition memory in those cases of amnesia where the damage is limited to the hippocampus or its diencephalic targets. Aggleton and Brown argue that this is entirely consistent with the literature from experimental lesions in animals, most of which indicates that recognition memory is unimpaired by lesions limited to the hippocampus, but is impaired when extrahippocampal regions are damaged, such as the perirhinal cortex and related regions. This view is strongly opposed by Reed and Squire (1997), who report a series of patients for whom the damage is "limited primarily to the hippocampus or the hippocampal formation," and who show clear evidence of impaired recognition. As Aggleton and Brown point out, however, the crucial question is that of whether areas beyond the hippocampus were indeed completely preserved; something that is difficult to establish, particularly in view of the fact that brain areas that appear to be structurally intact when imaged using MRI may show reduced functional activity when studied using PET (Aggleton & Brown, 1999). Jon's syndrome of amnesia combined with apparent sparing of recognition memory might thus be claimed to stem from a reduction in the development of the hippocampus, together with apparent sparing of other brain tissue associated with memory function (Gadian et al., 2000; Mishkin et al., 1998; Vargha-Khadem et al., 1997), hence, to be consistent with the hypothesis proposed by Aggleton and Brown. However, the principal function of the present study is to explore the functional rather than the anatomical characteristics of Jon's memory deficit and to discuss its relevance to the apparent preservation of his semantic memory development.

Problems in Comparing Recall and Recognition

As demonstrated by Mandler, Pearlstone, and Koopmans (1969), it is clearly unsatisfactory to assume that tasks based on recall and recognition of the same material will be equivalent in difficulty, as measured by percentage of correct responses. One way of attempting to circumvent this is to attempt to adjust the difficulty of one task so that it appears to give a score equivalent to that on the other. Calev (1984), for example, adjusted the level of recall and recognition by using categorized words for recall and unrelated words for recognition. This of course introduces potentially important differences between the two tasks. This procedure is also open to the objection that it assumes that having found one point at which the distribution of scores from the recall and recognition methods give a similar percentage, then the rest of the distribution of scores will also be equivalent. This is not necessarily the case. Shallice (1988) makes a similar point in challenging the claim by Hirst et al. (1986) of having demonstrated a recall–recognition dissociation in amnesic patients, pointing out the way in which a difference in variance between two measures could also give rise to a spurious apparent dissociation. The absence of any differential effects of amnesia on recall and recognition in most instances was further supported by a thorough study by Haist, Shimamura, & Squire (1992).

To avoid the earlier problems in comparing recall and recognition, Baddeley, Emslie, and Nimmo-Smith (1994) attempted to produce tests of visual and verbal recall and recognition of equivalent difficulty by using scaled scores. Such scores express a patient's performance on each test in terms of Z scores based on the distribution of normal population scores on that test. Using this method, separate measures of visual and verbal memory, and of recall and recognition, may be obtained together with measures of learning and forgetting. The test has proved sensitive to a range of factors known to influence episodic memory, including Alzheimer's Disease, normal aging, and schizophrenia (Baddeley, 1996); the test is also able to differentiate between the effects of right and left temporal lobectomy on visual and verbal memory (Morris, Abrahams, Baddeley, & Polkey, 1995).

Less dramatic visual–verbal memory differences were also found in other groups, with the elderly tending to be more impaired on names than on visual stimuli, while the opposite pattern occurred for schizophrenic patients (Baddeley, 1996). On the other hand, there has so far been no evidence reported for a marked recall–recognition difference for either etiological groups or individuals within the various groups. Since the subjects assessed using the test have varied markedly in memory ability, from elderly Alzheimer patients (Greene et al., 1996) to young Ph.D. students (Baddeley, 1993), this suggests that any recall–recognition discrepancy observed is unlikely to be an artefact resulting from ceiling or floor effects.

RECOGNITION TEST PERFORMANCE

Doors and People Test

We began by testing Jon on the Doors and People Test, a relatively pure test of visual memory using recognition of sets of photographs of doors, and recall by drawing of four different versions of a cross (Baddeley et al., 1994). These visual memory tests are then contrasted with verbal recognition and recall based on people's names.

The results are shown in Figure 1, where performance on the four subtests is expressed in terms of scaled scores; a score of 10 represents the population mean for subjects of Jon's age, with each scaled point representing one-third of a standard deviation. For both visual and verbal recall memory, Jon scores below the 5th percentile, while scoring between the 50th and 75th percentile for recognition. Neither of the control subjects show a clear recall–recognition discrepancy. The various scores can be combined to estimate the likelihood of finding a visual–verbal or recall–recognition discrepancy of this magnitude within the population. In the case of the visual–verbal distinction, Jon has a scaled score of 10, Andrew a scaled score of 9, and Max a score of 9; hence,

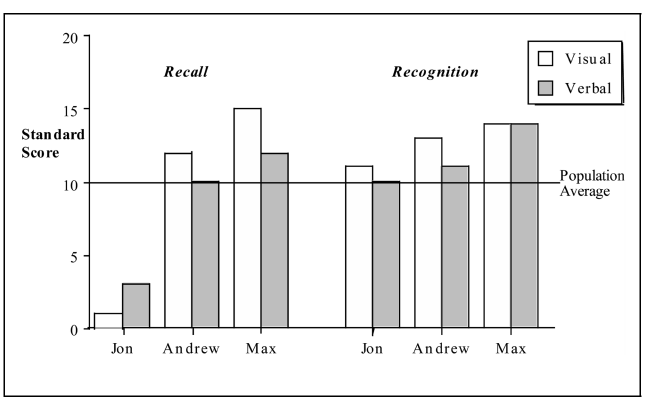

Figure 1. The performance of Jon and two control subjects on the Doors and People Test of Visual and Verbal Recall and Recognition. Jon scores at the average level on both recognition tests, but is impaired on the two recall measures.

none of the three show a clear difference in performance between pictorial and verbal material. In the case of the recall–recognition distinction, however, the discrepancy gives a scaled recall–recognition difference score for Jon of below 3, which represents the bottom of the scale on this particular test measure. In contrast, Andrew and Max both have scaled scores of 9, placing them within one-third of a standard deviation of the population norm.

The results of the Doors and People Test indicate a marked discrepancy in Jon between clearly impaired recall and recognition performance that is entirely within the normal range. However, in discussing the claims for a recall–recognition discrepancy in patients with damage limited to the hippocampus, Reed and Squire (1997) criticize Aggleton and Shaw for relying too heavily on a limited range of tests, and on relatively short tests with immediate recognition. For that reason, we extended our investigation to cover three further tests, one of which uses auditory presentation and rapid paced recognition (Andrade, Munglani, Jones, & Baddeley, 1994; Andrade, 1996; Shepard & Teghtsoonian, 1961), while the others are tests developed by Squire and his collaborators with the explicit purpose of involving a reasonably long sequence of words, together with an interpolated delay (Hamann & Squire, 1997). None of these tests have standardized norms, but in all cases, data from normal control subjects are available, as are data from Andrew and Max.

Continuous Recognition Test

Shepard and Teghtsoonian (1961) developed a test in which a sequence of words is presented, and the subject is required to perform a running recognition task, deciding when each word is presented, whether it has been shown previously. Repetitions can occur immediately, or after 1, 2, 4, 8, or 16 intervening words.

Despite the rapidly paced presentation, Jon detected all repetitions with the exception of one at a delay of four, and two at an eight-word delay. Jon's score of 97.3% is slightly higher than the scores of Andrew (86.5%) or Max (83.0%) and exceeds the mean scores of 92.9% and 94.4% reported for normal subjects (anesthetists) in two studies by Andrade et al. (1994) and Andrade (1996). However, Jon made an average of 0.5 false alarms per list compared with 0.31 by Andrew, none by Max, and an average of 0.20 reported by Andrade et al., although Jon's score was within the range observed in that study. Because of the nature of the test, the probability of a repetition increases as the list progresses, making a bias-free estimate of memory problematical. The next two tests avoid this problem in two different ways, one by using two-alternative forced choice, where a single response is always required, and the other by holding the probability of a target constant at 0.5 and noting both detection and false alarm rates.

Delayed Recognition Tests

The next recognition tests comprised the yes–no recognition and two-alternative forced-choice recognition measures used by Hamann and Squire (1997), both tested after a 5-min filled delay.

Figure 2a shows Jon's performance on forced-choice recognition, together with data from Andrew and Max and from Hamann and Squire, illustrating the overall level of performance from their amnesic and control groups, based on six separate tests given over 2 days. Jon's performance is very close to that of the two age-matched control subjects and of Hamann and Squire's control subjects, and substantially above that of their amnesic patients.

Figure 2b shows the equivalent data for yes–no recognition performance. In the case of forced-choice recognition, performance is measured by simple percentage correct. In the case of yes–no recognition, hits and false alarms are combined to create d', a measure of discrimination accuracy; Jon's average detection probability is .813, while his average false alarm rate is .201 giving him a d' score of 1.76. As is clear from Figure 2b, Jon's performance broadly resembles the average of Hamann and Squire's control subjects (mean d' = 1.89) and falls between that of Andrew (d' = 1.19) and Max (d' = 2.12). Performance on this task was highly variable, with Andrew and one of Hamann and Squire's control subjects scoring below the level of one of their amnesic patients. This suggests that subjects may have difficulty in setting an appropriate criterion, since performance under forced-choice conditions, which remove the problem of criterion, does not show this variability.

To this point, we have reported Jon's scores on a range of recognition tests, both visual and verbal. On all of these, Jon has performed at, or even somewhat above, the average level to be expected from a normal subject. Method of testing has included both forced-choice and yes–no recognition, tested both immediately and after a 5-min filled delay. Finally, recognition has been tested under both unpaced and rapidly paced conditions. We therefore feel reasonably confident in claiming that despite clear evidence of his amnesia, Jon has a well preserved recognition memory. As Reed and Squire (1997) point out, such a dissociation is certainly not typical of the amnesic syndrome. Jon is therefore atypical in two respects; first, in his recall–recognition disparity, and second, in his spared capacity to increment semantic memory despite his episodic memory deficit, which again is not characteristic of the amnesic syndrome (Squire et al., 1993).

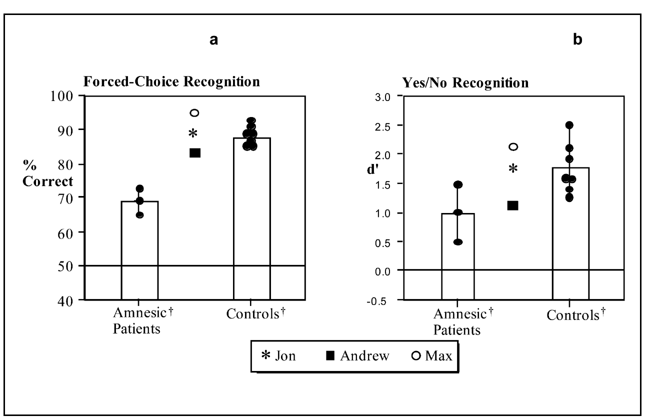

Figure 2. Delayed verbal recognition memory as measured by two-alternative forced-choice (a) and yes–no (b) recognition. On both measures, Jon resembles the normal control subjects rather than the amnesic patients of Hamann & Squire (1997).

At this point, we encounter an apparent paradox. Jon's semantic memory is not limited to his ability to recognize facts about the world. He is quite capable of recalling the information necessary for defining words, can recall the names of historic figures, and discuss at considerable length issues such as current politics. All these suggest that it is not the capacity to recall per se that is impaired, but rather the ability to use episodic memory in order to facilitate the recall of newly acquired material such as lists of unrelated words presented once. The fact that Jon has acquired an extensive amount of semantic knowledge suggests that learning, whether tested by recall or recognition, should be possible under conditions where naturalistic material is presented on multiple occasions. While it is clearly impractical to simulate adequately a lifetime of rich experience, we went some way in this direction by presenting Jon with a series of videos based on newsreels of events from the years 1937 and 1957. One of these, 1937, was presented four times distributed over a 2-day period, while the other was presented only once. Both recall and recognition were tested immediately after the final presentation in each case, and were retested the following morning after an interval of approximately 18 hr.

The results shown in Figure 3 indicate first of all that after a single presentation, Jon's immediate recognition performance is comparable to that of the control subjects, and even his overnight recognition is only slightly below theirs. His immediate recall score, by contrast, is clearly much lower than theirs. However, after four presentations, Jon's immediate recall score has risen substantially, and indeed, slightly exceeds that of Andrew, while all three show a modest increase in recognition scores. It is clearly the case, therefore, that Jon's recall deficit can be minimized given sufficient practice.

The overnight recall data are somewhat more difficult to interpret, since there is evidence to indicate that successfully performing a recognition test can enhance subsequent recall. This probably occurs because the presentation of recognition alternatives may provide a reminder, which in turn acts as a relearning trial. For example, one of the 1937 questions concerned a Zeppelin disaster, asking for the name of the craft involved, and subsequently providing four alternatives, the Bis-

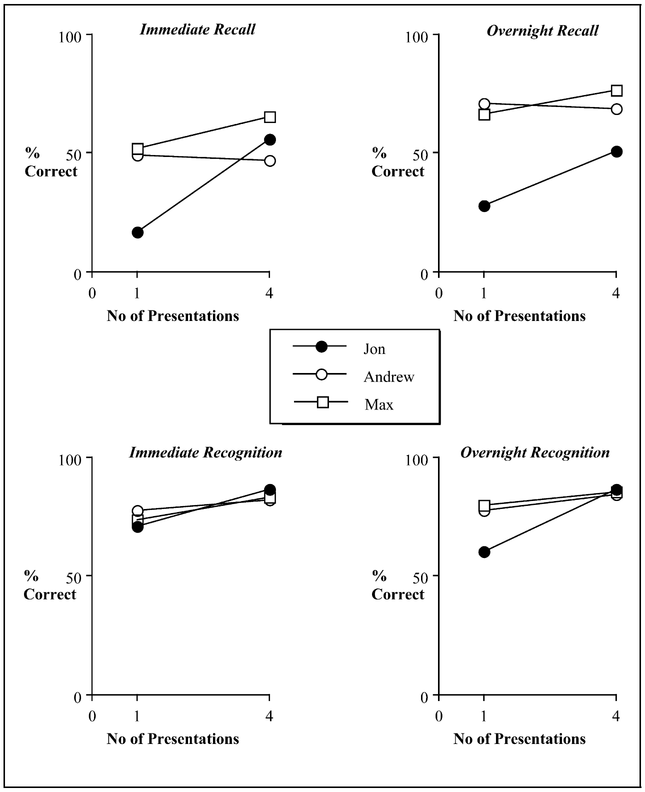

Figure 3. Recall and recognition of events from unfamiliar news videos viewed on one or four occasions and tested immediately or after an overnight delay.

mark, the Mecklenburg, the Deutschland, and the Hindenberg. Having been reminded of a correct answer that could not be recalled, the subject may then retain the information. The most important feature of these results, however, is the fact that Jon is able to retain the information he has acquired across the overnight delay of 18 hr, whether tested by recall or recognition; long-term retention of newly acquired knowledge is, of course, a necessary feature for the incrementation of semantic memory.

While variables that influence recall typically also affect recognition, the question of whether they reflect equivalent processes has remained controversial, at least since Mandler (1980) proposed a two-component interpretation of recognition. He proposed that a target word might be subsequently recognized on the basis of either the recollection of having encountered that word, e.g., because it reminded one of the earlier learning experience, or alternatively, simply on the basis of a feeling of familiarity. This line of discussion was further developed by Tulving (1985), who defines episodic memory in terms of the subjective experience of recollection. He proposed that requiring subjects to judge whether they truly "remember" a word, or simply "know" that it was previously presented may prove to be a productive way of investigating episodic memory. This has indeed proved to be the case, with a whole range of variables including age, type of processing, and degree of attention influencing "remember" judgements while having little influence on "know" responses (Baddeley, 1997; Gardiner & Java, 1993).

A possible interpretation of our results is to assume that while Jon retains the capacity to acquire new information as reflected by a greater sense of familiarity and general accessibility, he lacks the capacity to recollect the learning experience, leading to the absence of associated sensory and contextual information that enables subjects to say they "remember" an event, rather than simply "know" that it happened.

We attempted to test this interpretation, spending a considerable time trying to explain to Jon what it means to "remember" something, as opposed to simply knowing that it had been presented earlier. We explained that the "remember" judgement is to be given whenever a recognized word reminds the subject of the learning experience, e.g., the word "dachsund" might be remembered because of recalling that when it was presented it reminded the subject of a friend's pet seen last week, or perhaps because it seemed to be associated with an earlier item such as "sausage." We tried to get Jon to recollect events such as his journey to the Institute that morning. He gave a relatively detailed account but was unable to provide any specific detail that might differentiate this from previous journeys. He indicated, for instance, that he had attempted to run up the final flight of stairs in one rush, and had got just over halfway. However, when asked how he knew this, he replied "I always get about halfway." We nevertheless decided to proceed, using material and testing procedures taken from Parkin and Walter (1992), in which words are presented for learning and then tested by yes–no recognition, with subjects categorizing the "yes" responses as being "remembered" or "known." This method has the safeguard of subsequently checking a subsample of "remember" judgements and requiring the subject to give the reason for his judgement. In terms of overall performance, Jon had a hit rate of .917 and a false alarm rate of .194, giving him a d' score of 2.25. This is slightly lower than the d' obtained by the young control subjects (mean = 2.70, *SD* = 0.7), but clearly higher than that obtained by the normal elderly subjects (d' = 1.90, *SD* = 0.8). At first sight, Jon appeared to be using the "remember" judgement even more readily than the young, and substantially more often than the elderly subjects. However, in each case, when subsequently asked why he gave the "remember" judgement, he provided the same account, namely that he looked at the word, tried to imagine it printed on the stimulus card, and if this resulted in an immediate and clear image, gave a "remember" response. Such a method is much closer to the use of perceptual fluency, a method commonly associated with implicit rather than recollective memory (Whittlesea, 1993). The fact that we were unable to train Jon to use the "remember/know" distinction appropriately is entirely consistent with the hypothesis that he lacks the capacity to recollect the contextual detail necessary for an appropriate ''remember'' response. However, a conclusion that relies on a failure to teach the subject to use a relatively subtle concept clearly does not provide adequately strong evidence concerning the hypothesis. Further investigation is ongoing (see below), based on the question of whether Jon exhibits the electrophysiological pattern that has been shown to be associated with ''remember'' judgements (Rugg, Schloerscheidt, & Mark, 1998).

DISCUSSION

Despite Jon's impaired memory when measured on tests that rely on recall, his recognition memory was found to be normal across a range of tests involving different materials, speeds of presentation, and recognition paradigms. The single exception was his slightly lowered score for overnight recognition of items on the newsreel presented only once. On the basis of this, we would claim that Jon's recognition memory performance falls within the normal range. More specifically, his recall and recognition scores on the Doors and People Test explicitly designed to allow a recall–recognition contrast, demonstrate very clearly impaired recall and preserved recognition. Such a dissociation is not attributable to the differential sensitivity of the two measures, since it is not shown by Alzheimer's disease patients (Greene et al., 1996), by schizophrenic patients or normal elderly subjects (Baddeley, 1996), or by a group of patients recently reported by Manns and Squire (1999), selected as having lesions that are located principally in the hippocampus.

With the single exception noted above, Jon's recognition performance is consistently within the normal range; can we therefore conclude that his performance is unimpaired? This would be unwise; Jon has above-average intelligence, is highly motivated, and is an experienced and sophisticated subject. He does, for example, attempt to optimize his guessing by keeping count of the proportion of ''yes'' responses he makes. It is thus possible that, in the absence of neurological damage, he would have performed above average. The important feature of Jon's case, therefore, is the clear dissociation between recall and recognition rather than the seemingly complete preservation of recognition performance. It is important to bear this in mind, both when seeking to replicate our findings and in considering possible theoretical explanations.

If we accept that the dissociation is indeed genuine, what are its implications for the recall–recognition distinction and for understanding the specific association of symptoms found in Jon, namely impaired recall memory coupled with preserved language, semantic memory, and intelligence? It is initially tempting to argue that the preservation of recognition in the presence of clearly impaired recall suggests that they reflect two separate memory systems. This would be premature for two reasons. First, our results are based on a single dissociation rather than the much more powerful double dissociation, for which we would need a case in which recall is preserved and recognition impaired. Second, it is important to bear in mind that recall and recognition are experimental methods of tapping memory, not themselves direct measures of underlying memory systems, although they may differ in their relative reliance on underlying systems. Finally, however, Jon clearly is capable of recalling a good deal of information of both a semantic and personal semantic nature, suggesting that recall per se is not necessarily defective.

It seems more productive to consider interpreting our findings in terms of the processes underlying recall and recognition. It is now widely accepted that human long-term memory is not unitary, reflecting at least two underlying processes or systems. One involves the conscious recognition and recall of previously experienced events or facts, termed by Squire and Zola (1998) as declarative memory. This system, in which the subject is aware of the fact that he or she is remembering, may be contrasted with a range of nondeclarative or implicit memory processes in which prior learning is reflected indirectly through enhanced performance. Nondeclarative memory may, for instance, occur in the acquisition of skills, classical conditioning, and a range of perceptual priming effects. In general, amnesic patients show preserved performance on these implicit memory tasks together with impaired performance on explicit or declarative measures (Squire et al., 1993).

It is now generally accepted that recognition memory itself reflects at least two underlying processes, one recollective, and based on the capacity to associate the recognized item with some aspect of its original presentation (''remembered'' items), while the other is more automatic (''known'' items), possibly based on a general feeling of familiarity (Tulving, 1985; Mandler, 1980). As discussed earlier, one method of accessing the recollective component is through asking the subject to decide whether the item they have recognized is ''remembered,'' or whether it is simply ''known'' to have been presented (Gardiner & Java, 1993). A second approach is based on requiring the subject to make a judgement based on list membership, with instructions and interfering lists so arranged that under certain circumstances, a knowledge of list membership will help, while in others, it will hinder performance—the so-called *process dissociation method* developed by Jacoby (1994). There is some disagreement as to whether the two methods are equivalent (see Baddeley, 1997, chapter 20 for a discussion). However, recent work using electrophysiological methods has claimed that the two approaches are both ways of accessing contextual or source memory, and ultimately rely on equivalent underlying processes (Rugg et al., 1998).

Our failure to teach Jon to make the remember/know distinction suggests that Jon may lack the capacity to utilize this recollective source of evidence. Yet he appears to have no difficulty in judging whether or not an item was presented before, presumably on the basis of the presence or absence of a feeling of familiarity. Evidence consistent with these notions was obtained in an electrophysiological study that was recently carried out on Jon (Düzel, Vargha-Khadem, Heinze, & Mishkin, 1999). This preliminary report indicated that during recognition performance, Jon exhibits the electrophysiological index that has been associated with stimulus familiarity, but he appears to lack the one that normally accompanies episodic recollection of the stimulus item. The latter process may normally aid in recognition, and so its possible absence or impairment in Jon could well be reducing his recognition scores below those he would otherwise have been able to achieve. It might account, for example, for his relatively low score on overnight recognition of the newsreel items presented only once, the single instance in which he may have shown a recognition deficit. Yet the absence or impairment of episodic recollection clearly did not prevent Jon from attaining scores that fell well within the normal range on every other measure of recognition memory with which he was assessed here.

The recall involved in well-established semantic memory, which may be conceived as decontextualized, likewise does not require, and, indeed, may not greatly benefit from, the recollective process. By contrast, episodic recollection is clearly of major importance for the recall of newly presented material. Thus, an impairment in episodic recollection could explain Jon's poor performance on standard recall tests, which are typically assumed to rely heavily on the capacity for recollection. Similarly, inasmuch as episodic recollection presumably facilitates and enhances the recall of newly acquired semantic information, an impairment in recollection could also be the reason that Jon had difficulty in recalling the items of information contained in the newsreel that was shown to him only once. However, on the newsreel that was presented four times over a 2-day period, a procedure that decontextualized the learning experience at least with respect to time, and thereby presumably decreased the importance of episodic recollection for recall, Jon's recall scores relative to those of the control subjects improved substantially. There is therefore good reason to suppose that just such repetition, even when limited in frequency, is what has enabled Jon to acquire, and recall, his very large store of semantic information.

We should end by considering the generality of the findings we have obtained in Jon. It seems likely that the preservation of recognition relative to recall of new material may potentially occur more widely among developmental cases (Vargha-Khadem et al., 1997). It is also reported in a few cases of acquired amnesia (Aggleton & Brown, 1999), although such cases are highly atypical (Squire et al., 1993) and the claims of selective preservation can be criticized on the grounds of uncertain comparability between the recall and recognition measures (Manns & Squire, 1999; Hamann & Squire, 1997). However, Holdstock et al. (2000) recently reported the case of a patient with acquired hippocampal damage who, like Jon, shows preserved recognition relative to recall performance on the Doors and People Test.

Jon's capacity to acquire semantic memory is also atypical of acquired amnesic patients (Gabrieli, Cohen, & Corkin, 1988; Rozin, 1976). Although there does appear to be limited evidence for preserved semantic acquisition in some patients, the extent of such learning is far from normal (Verfaellie, Koseff, & Alexander, 2000; Kitchener, Hodges, & McCarthy, 1998). It is therefore conceivable that Jon's preserved abilities are based, not only on the selectivity of his hippocampal damage, but also on the developmental nature of his deficit reflecting the greater plasticity of the infant brain, together with the possible development of a range of alternative learning strategies as suggested by Manns and Squire (1999). This question will not be settled until it becomes clear whether the pattern of preserved recognition in association with spared acquisition of semantic memory is limited to cases of developmental amnesia, or whether this pattern can also occur in cases where the amnesic deficit is acquired during adulthood.

METHODS

The following tests were administered. They required a number of test sessions distributed over a period of weeks.

The Doors and People Test

The visual recognition test involves presenting colored photographs of 12 doors, one at a time, each accompanied by an appropriate but ultimately unhelpful label, for example "church door" or "barn door" (Baddeley et al., 1994). Recognition is tested immediately by presenting 12 successive arrays of four doors, in each case requiring the subject to identify the door already presented. By ensuring that the items within each array all have the same label (e.g., church doors), the role of verbal labeling can be minimized. Two different sets of 12 doors are presented and tested in succession. The visual recall task involves presenting and requiring the subject to copy four crosses, each distinguished by the features comprising the overall shape and the presence or absence of elaboration at the crux and at the end of the arms of the cross. Subjects are shown the four crosses on three successive trials, each immediately followed by a recall test. A final recall test follows after a filled delay of approximately 10 min. Verbal recognition is tested by presenting 12 names such as John Wilkins, which are subsequently tested by recognition from four-item sets (e.g., John Wilby, John Wilkie, John Wilkins, John Willis). Again, two sets of 12 items are presented and tested immediately after each set. Finally, verbal recall is tested by showing the subject pictures of four people: a minister of the church, a newspaper boy, a doctor, and a postman, and in each case, providing the first and second names. Again, there are three presentations, each followed by recall tests of the four names, cued by their occupations, then followed by delayed recall after a 10-min filled interval.

Continuous Recognition Test

In a version of the test developed to study memory under light anesthesia, each of 16 lists comprised 23 words, with two words repeated immediately, and one each repeating at delays of 1, 2, 4, 8, and 16 interpolated words (Andrade et al., 1994; Andrade, 1996). In order to increase the level of difficulty, the distractor words used were semantically associated with the target items. The words were read out at a rate of 2 sec per word, with the subject responding verbally whenever he detected a repetition.

Delayed Recognition Tests

For each of these tests, 24 target words were first presented for study on a computer visual display at a rate of 3 sec per item (Hamann & Squire, 1997). Each list was preceded and followed by three subsequently untested buffer words in order to minimize the effects of primacy and recency. At study, the subject read each word aloud, and after 5 min filled by conversation, recognition was tested. In the case of two-alternative forced-choice recognition, the subject was tested by being shown 24 word pairs, each comprising one item from the study list and one new item. He was asked to say aloud the word that he had been shown previously. In the case of the yes–no recognition test, a total of 24 old (studied) words and 24 new (unstudied) words were presented one at a time in mixed order; in each case, the subject was asked to say whether he had been shown that word previously or not. A total of six test lists were given for each of the two conditions, beginning with three forced-choice lists, followed by three yes–no lists, followed by the remaining three forced-choice lists, and finally, the last three yes–no lists. The appropriate recognition instructions were given before each test list.

Newsreel Recognition and Recall Task

The test was based on presenting video clips based on excerpts from the Pathe Movie newsreels from 1937 and 1957, respectively. In each case, an initial section of approximately 35 min was presented. Testing took place over three successive days. The 1937 newsreel was presented on the morning and early afternoon of the first day, and the morning and late afternoon of the second. The 1957 newsreel was presented at the end of the afternoon of the first day. The 1957 newsreel was tested immediately after this single presentation and at the beginning of the next morning session, approximately 18 hr later. The 1937 newsreel was tested after its fourth presentation and retested on the morning of the third day, again after an 18-hr delay. The two newsreel tests each involved a total of 45 questions, each comprising a recall test, followed by a four-alternative forced-choice recognition test. Questions ranged from specific detail such as the names of people shown and numbers of people killed in a particular accident, to more general issues mentioned, such as the state of the economy at a particular time and the cause of particular accidents. Virtually all the information appeared to be novel for all subjects.

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