

UNCONSCIOUS PROCESSING IN MEMORY RECALL. A STUDY OF THREE AMNESIC PATIENTS

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INTRODUCTION

Everybody has experienced memory blocks: for instance, the lack of a word, the name of a person or place, or an intended action and its recall a short time later. The missing memory can suddenly reappear either as the result of an association of ideas or “spontaneously”, when he or she is thinking of something else, the word (or idea) “coming to mind” out of the blue. The work reported here considers only the last circumstance. Such a process, similar to “automatic mechanism” in memory blocks (Meichenbaum and Gilmore, 1984; Reason and Lucas, 1984), suggests the following hypothesis: unconscious search activity would be activated and would work to reach the target. Once the specific pattern of the missing memory is reached and activated, the word (or the idea) suddenly emerges.

The unconscious nature of the retrieval mechanism is difficult to demonstrate convincingly in normal subjects for two main reasons: first, memory blocks are rare and unpredictable; second, one cannot be certain that between the memory block and the delayed recall, the subject has not consciously thought about the missing information, a search that is natural and difficult to prevent even with the instruction “Don’t think about it”.

Patients with a pure amnesic syndrome (AS) represent a good alternative for studying unconscious retrieval, since they show many memory blocks, due to retrograde amnesia, and are prevented from consciously thinking about them by their anterograde amnesia.

In order to exploit this opportunity, we have devised a new method for investigating whether amnesics could be induced to perform an unconscious search of missing memories and whether the outcome of the search was related to the nature of the to-be-retrieved material.

The term unconscious is used here in its common meaning: neurophysiological processes whose existence is inferred through behavior but whose contents are not available to conscious mind. It is considered here as a retrieval activity and not a storage activity (Kihlstrom, 1984; Robinson, 1984).

We report three patients affected by a pure AS and who were examined to assess the above mentioned hypothesis.

TABLE I
Memory and I.Q. of the Three Patients

	Wechsler memory scale	Paired associates	Visual memory	Logical memory	Span	I.Q.
Patient 1	69	11.5 (15/4)	1	3 (4/2)	11 (6/5)	111
Patient 2	63	4.5 (5/2)	1	6.5 (9/4)	8 (4/4)	108
Patient 3	83	8.5 (13/2)	8	3.5 (4/3)	14 (8/6)	>130

The numbers in parentheses correspond respectively to the "easy" and "difficult" recall in the subtest "Paired associates" and to the first and the second story in the subtest "Logical memory" (the delayed recall exploration was not used). Span refers to Digit Span (forwards, backwards). The I.Q. correspond to the results obtained with the Raven's Progressive Matrices (PM) 47 in patient 1 (=33) and with the PM 38 in patients 2 and 3 (respectively=43 and 56).

MATERIAL AND METHOD

Patients

The 3 amnesic patients had a rather pure syndrome without behavioral disturbances, intellectual impairment, aphasia, visual agnosia or frontal syndrome. Neurological examination was normal. Both anterograde amnesia (AA) and retrograde amnesia (RA) were severe (Table I). Patients were tested from 6 months to 4 years after their cerebral injuries. During the period of the sessions, the AS was unchanged.

Patient 1

A 45 year-old housewife suddenly complained of headache and nausea due to a subarachnoid hemorrhage. Angiography showed an aneurysm of the anterior communicating artery with spasm of both anterior cerebral arteries. At operation the aneurysm was clipped and both gyri recti were excised. The patient experienced severe post-operative amnesia. Testing was carried out six months later. AA and RA were persistent and severe, without anosognosia (Table I).

Evolution. The AS slowly improved. Five years later, AA had completely disappeared but RA still impaired the precision of her memories.

Patient 2

A 37 year-old female teacher had two generalized convulsive seizures. CT showed a left thalamic lesion. A stereotactic biopsy, which was followed by a transient right-sided hemiplegia and aphasia, was unrevealing. Radiation therapy was given and severe amnesia developed. Magnetic resonance imaging (Figure 1, A) showed extensive areas of high signal involving, on the left side, the hippocampus, the thalamus and the white matter of the frontal lobe, including the cingulate gyrus, and, on the right side, the white matter of the anterior part of the cingulate gyrus and the anterior part of the corpus callosum. The images were compatible with a low-grade glioma or post-radiation necrosis. The test was undertaken three years later. RA and AA were severe without confabulation or anosognosia (Table I).

Evolution. Five years later, the residual AS was mild. The true nature of the lesions remained undetermined.

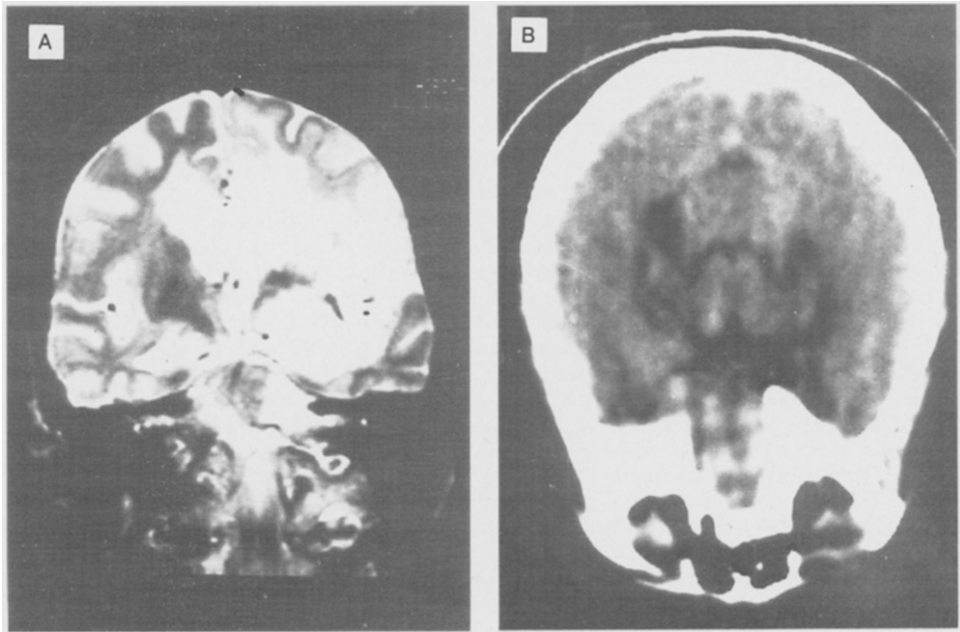


Fig. 1 – A. Patient 2. MRI: high intensity signals involving, on the left side, the hippocampus, the thalamus and the white matter of the frontal lobe including the cingulate gyrus, and, on the right side, the white matter of the anterior part of the cingulate gyrus and the anterior part of the corpus callosum. B. Patient 3. CT scan: images of severe alterations of the medial part of both temporal lobes.

Patients 3

A 20 year-old woman was admitted for coma and fever due to herpes simplex encephalitis. When she recovered consciousness, she was severely amnesic. CT showed low density areas in the medial parts of both temporal lobes (Figure 1, B). Two years later, positron emission tomography with 18 FDG displayed low bitemporal activity. The test was undertaken 4 years after the encephalitis. AA was severe but RA more than AA, without confabulation or anosognosia (Table I).

Evolution. Severe amnesia persisted. RA remained worse than AA. The patient could carry out simple tasks, but she had to write down everything she had to do.

The 2 patients had been subjected to cognitive rehabilitation programs lasting respectively 5 months, 3 and 4 years with poor result.

Locus of Lesion

In all 3 patients, the lesions involved the hippocampo-mammillothalamic (HMT) system: in patient 1, probably the fornix and septal nuclei (Taland, Sweet and Balantine, 1967; Alexander and Freedman, 1984; Milner and Petrides, 1984; Damasio, Graff-Redford, Eslinger et al., 1985; Baddeley and Wilson, 1986); in patient 2, the entire left HMT system and a small part of the right cingulate gyrus white matter (Whitty and Lewin, 1960); in patient 3, both hippocampi. In this case, the residual AS was unusual: while her anterograde memory had recovered to some extent (her scores were better than those of the 2 other patients), RA remained more severe than AA.

Procedure

The procedure consisted of exploring three topics during 4 sessions separated by a few days. The patient's performance was compared with that of normal matched controls.

Topics

The three topics concerned memory of a place (Topic I), an itinerary (Topic II) and an outstanding day in the patient's life (Topic III). For each patient, the content was based on close familiarity evidenced by the following: repeated exposure, personal motivation and emotional impact for Topics I and II; outstanding day and its emotional impact for Topic III; frequent presence of these Topics in the patient's mind before the cerebral injury. The following subjects were chosen from separate interviews with the patients and their families.

Patient 1. Topic I: Passy, the residential neighborhood of Paris where she had lived for 5 years, 10 years prior to her cerebral injury. Topic II: the itinerary of a roundtrip journey by car from Paris to Poitiers-Gencay, her native region and vacation home, 380 km from Paris to which she had been driving at least twice a year since the age of 17. Topic III: the day of her marriage, a particularly outstanding event, since she married an Algerian wanted by the French authorities, as she was 7 months pregnant and, as, after the ceremony, her husband went away with a friend and came back home drunk.

Patient 2. Topic I: the Latin Quarter in Paris where she had been living for several years as a student. Topic II: the itinerary of her visits to Lozere, her native region, 480 km from Paris, where she regularly spent her holidays. Topic III: the day she learned that her mother had died in an accident in Israel and urgently left Paris for Tel Aviv.

Patient 3. Topic I: a restricted area of Passy, the residential district of Paris where she had been living for 15 years. Topic II: the itineraries around her grand-mother's place in Spain where she had visited regularly on holidays. Topic III: the day her fiancé broke off their engagement.

Three points concerning these topics must be mentioned. 1) The topics were selected with the aim of investigating semantic and episodic memory (Wood, Ebert and Kinsbourne, 1982; Cermak, 1984; Tulving, 1984). The material included in Topics I and II was close to semantic memory (Bahrick, 1983; Bartram and Smith, 1984), while autobiographical data included in Topic III were mainly episodic memory (De Renzi, Liotti and Nichelli, 1987) even though this correspondence is not exact (Butters and Cermak, 1986) and there exist shifts from episodic to semantic memory. 2) The familiarity with the topics could not be quantified but could be evaluated with the given criteria. For Topics I and II, the similar exposure is not a sufficient condition, i.e. people working in a town district do not have the same familiarity with this district as people living in it. A similar emotional and/or motivational involvement is necessary too. The criteria used for the selection of controls ascertained it (see below). The question was more complex for Topic III. The day of life was lived together by the patient and her control. Their memories are basically personal matters. However the familiarity was similar: both patient and control were exposed to the same events, and they were both emotionally involved. 3) As was anticipated, the number of pieces of information was lower than those in Topics I and II. This difference did not introduce a methodological difficulty since the amount of data was only compared with that of the control, whose recalled memories were also lower for Topic III than for Topics I and II. For the 3 Topics, most of the items given by the patients were also given by the controls, supporting *a posteriori* an adequate selection.

Matched controls

For each patient a normal control subject was selected who had the same degree of familiarity with each concerned topic as the patient. For this reason, they were members of the patients' family for Topic III, but not necessarily for Topics I and II. Their sociocultural level was similar to or higher than that of the patient. Controls were as follows. *Case 1*, Topics I

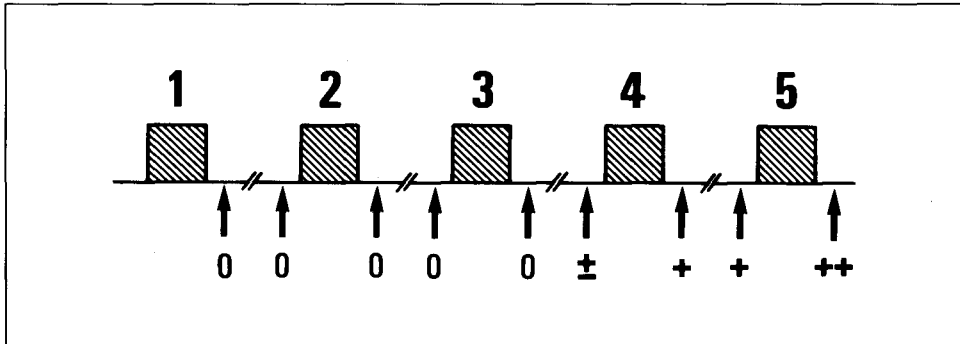


Fig. 2 – Testing schedule in patient 1. The sessions 1, 2, etc. are indicated by squares. At the beginning of each session, except the first, the examiner questioned the patient about the previous session(s) and, at the end, he investigated the recall of the just discussed topics. 0 = no recall, ± = recall of the names of the investigated topics; + to ++ = recall of the investigated topics with more or less details.

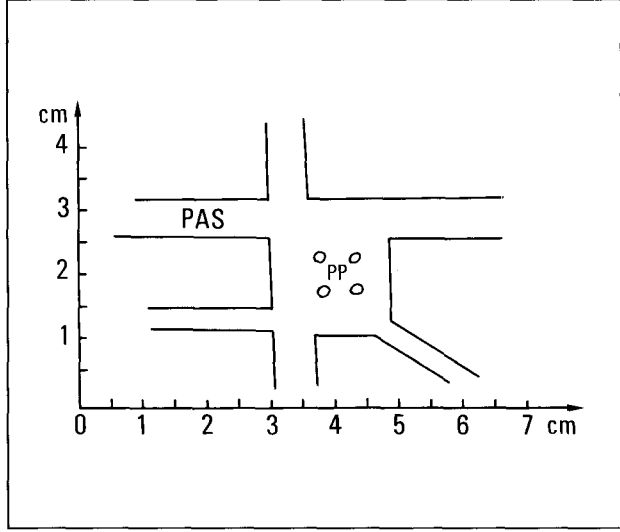
and II: a man who had been living in the Passy district for 22 years and had often driven from Paris to his country home near Poitiers-Gencay for 30 years; Topic III: the patient's aunt, who was her witness at her wedding. *Case 2*, Topic I: a former school mate of the patient at the University; Topics II and III: the patient's father who lived the same events as his daughter. *Case 3*, Topics I, II, III: mainly the patient's mother; her father checked a few pieces of information. For each topic, controls were questioned in one session whose duration lasted about one hour. Two controls underwent a second session for Topics I and III: their performances were equal to those of the first session and responses were given with the same words. The subjects had lost interest in the task. They stated that the content of the previous interview was still fresh in their mind, and that it interfered with the strict task of recollecting visual memories and with the talk about the event. Therefore, no attempt was made to retest the other controls.

Sessions

The experiment took place in 4 sessions, spanning over 8 to 12 days, and a fifth session carried out 3 weeks later. The schedule of the sessions was: patient 1, Topics I and II, on days 1, 3, 9, 12; Topic III, on days 1, 3, 6, 12; patient 2, Topic I, on days 1, 4, 8, 11; Topic II, on days 1, 4, 7; Topic III, on days 1, 4, 6, 8; patient 3, Topics I, II, III, on days 1, 4, 7, 9. The duration of the sessions had no time limit and lasted 2 to 3 hours. Each session included, on one hand, the interview about the studied topics or "test administration", and, on the other hand, the check of the forgetting of the previous sessions or "confirmation of AA" (Figure 2).

Test administration. It began by the statement of the topic to be discussed and instructions to the patient to express all she could remember about it. The examiner was not neutral, but, on the contrary, assertive in inciting the patient to make, when necessary, an effort of memory (as this effort may contribute to launch the process of unconscious search). A logical reasoning was frequently used: "You have just said that you have been settled for years in that district in Paris. Thus, you ought to remember the streets, the stores, etc., that were here, here and there on the map". And so on for each topic. All the other examples were taken from Patient 1's interviews. *Topics I and II.* The examiner always drew the same rough draft of a map with four or five pieces of visual information with only two or three pieces of verbal information (Figure 3). The examiner's question was: "This is the little square of Passy. Do you recognize it? What is there? And there?". Or "Here is Paris, here is Poitiers and there is Gencay. What was your route to drive to Gencay? Tell me about the cities, the villages and the various areas in the country". All the patient's answers, true or false, were re-

Fig. 3 – Patient 1, Topic I.
 In each session, the examiner drew his figure and said: “It’s the little square of Passy (PP) with its trees. There’s Passy Street (PAS). What do you remember about it and about the streets and buildings around it?”



corded by the examiner on the map, which remained in front of the patient. The examiner’s intervention was limited to active prompting devoid of new information. He could reiterate the data already given by the patient during the same interview: “You said that... what is close to it?” Or “What do you see in the same area? ... Can you describe this place?”. The examiner developed his questioning and enlarged the map according to the recollections of the patient. He could help the patient to find new points: “You said that...”. If the patient stopped giving information, the examiner drew another area of the district or of the itinerary in continuity with the first one, and so on. If the answers were satisfactory, the examiner

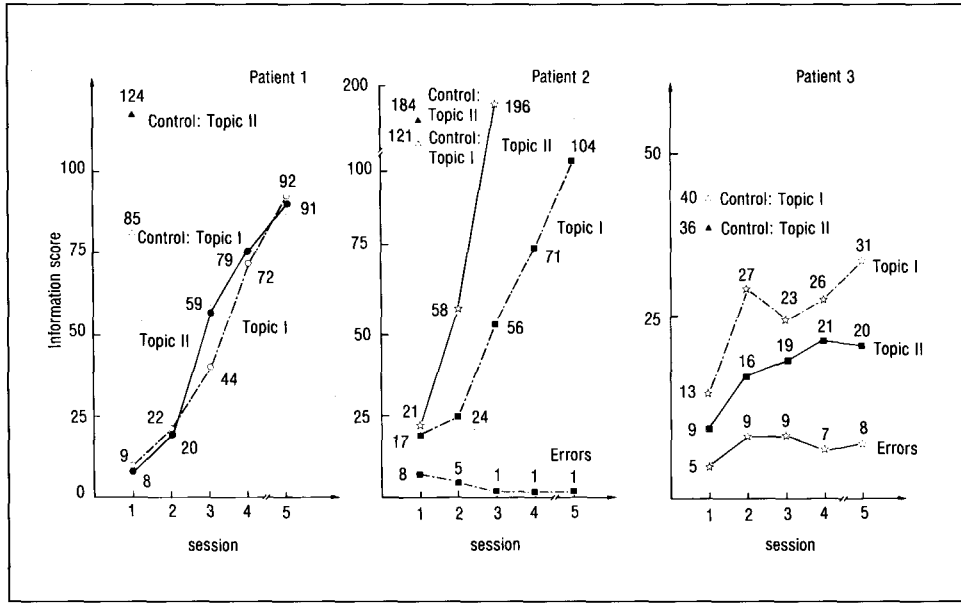


Fig. 4 – Topics I and II. Patient 1, 2 and 3. Abscissa: the sessions. Ordinate: the number of pieces of information. The results of normal subjects are indicated. Since patient 2 reached a very high recall score in Topic II in the 3rd session, the test was discontinued. Persistent errors were only observed in patient 3, Topic II.

asked more precise questions: “You said you had a coffee-break in this village, but where is the coffee-bar?... You said Notre-Dame church is there in Poitiers and that it has a beautiful style. Tell me what this style is and describe its facade”. In short, the drawing was enriched stepwise and the questioning did not contain any new information (“What is there?”), except that already given by the patient (“You just spoke about the Clain, a small river, in the village of Saint-Benoît. Where does it flow?”). *Topic III*. It was investigated only verbally. The examiner always started by asking: “On that day — the day of your wedding — where were you in the morning and what did you do first? At what time?”. Additional questions were triggered off by the last answer: “At what time did you go to the Town Hall? ... Can you describe it?”

The interview on a topic ended when the patient could not add any new pieces of information and could not respond to 5 successive prompting questions. All the questions and answers were noted and analysed later.

Confirmation of the AA (Figure 2). This consisted of assessing spontaneous recall and then recognition using a multiple choice list of the items that had been investigated. The inability to consciously retrieve elements of the previous session(s) was taken as evidence that the patient could not remember, think about and/or search for information between sessions.

This control of AA included 2 steps: first, at the beginning of each session (from the second session on), and, then, after a short filled delay (2 or 3 minutes) after the end of each test administration, at which time the patient was questioned about the topics just discussed. To avoid the passing on of any information concerning the topics, family members were not informed about them. After the procedure was over, the control of the effects of the AA was also checked by asking family members if the patient had spoken or questioned them about the topics between sessions. After the end of this study, the patients were not submitted to new tests on new topics. They would have had a different significance as the patients, aware of the procedure, were no longer naïve and might have been able to devise stratagems to think over the topics between sessions.

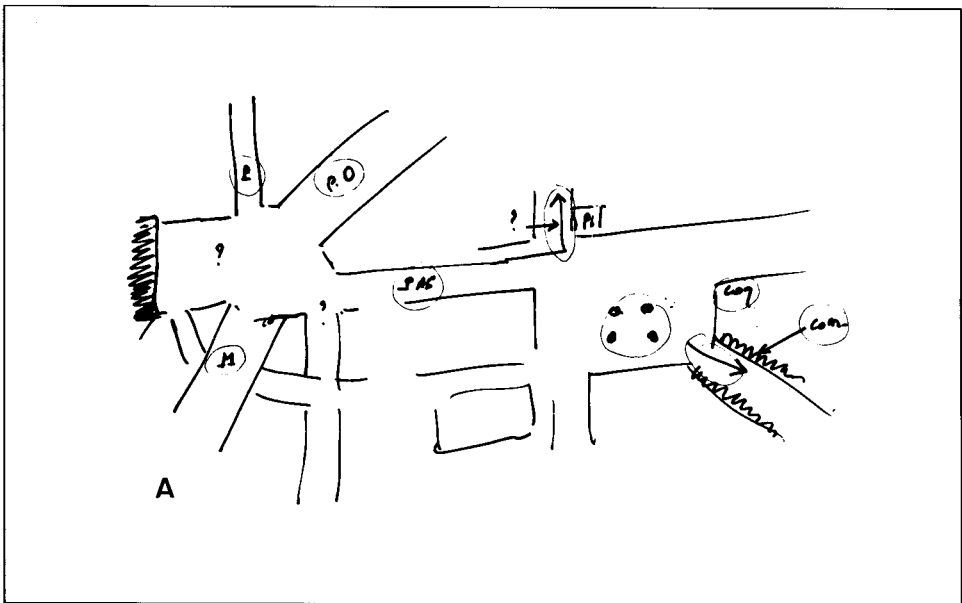


Fig. 5a – Patient 1, Topic I. The figures show the enrichment of the information from session 1 to 5. The pictures A (5a), C (5b) and E (5c) correspond to the first, third and fifth (control) sessions.

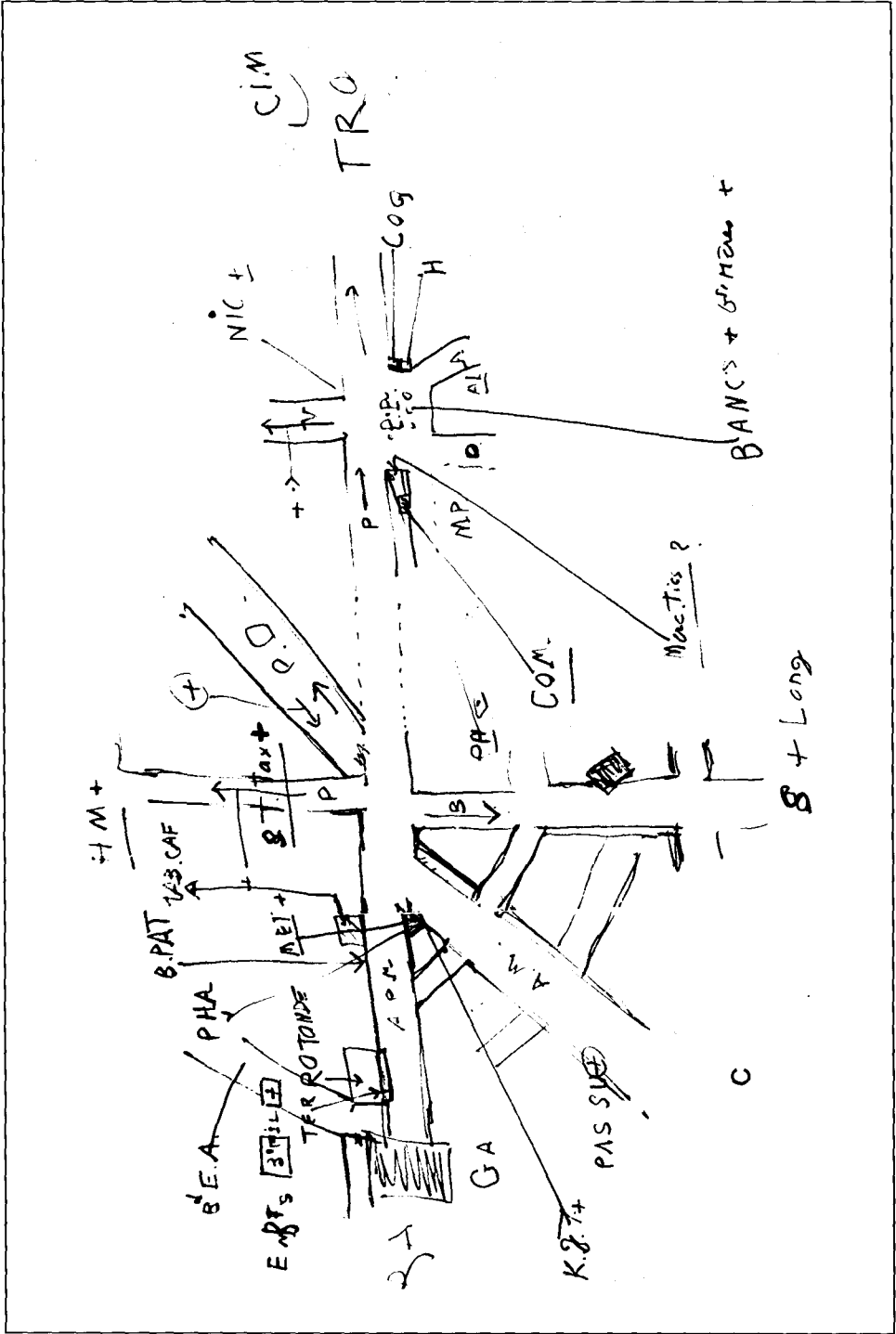


Fig. 5b

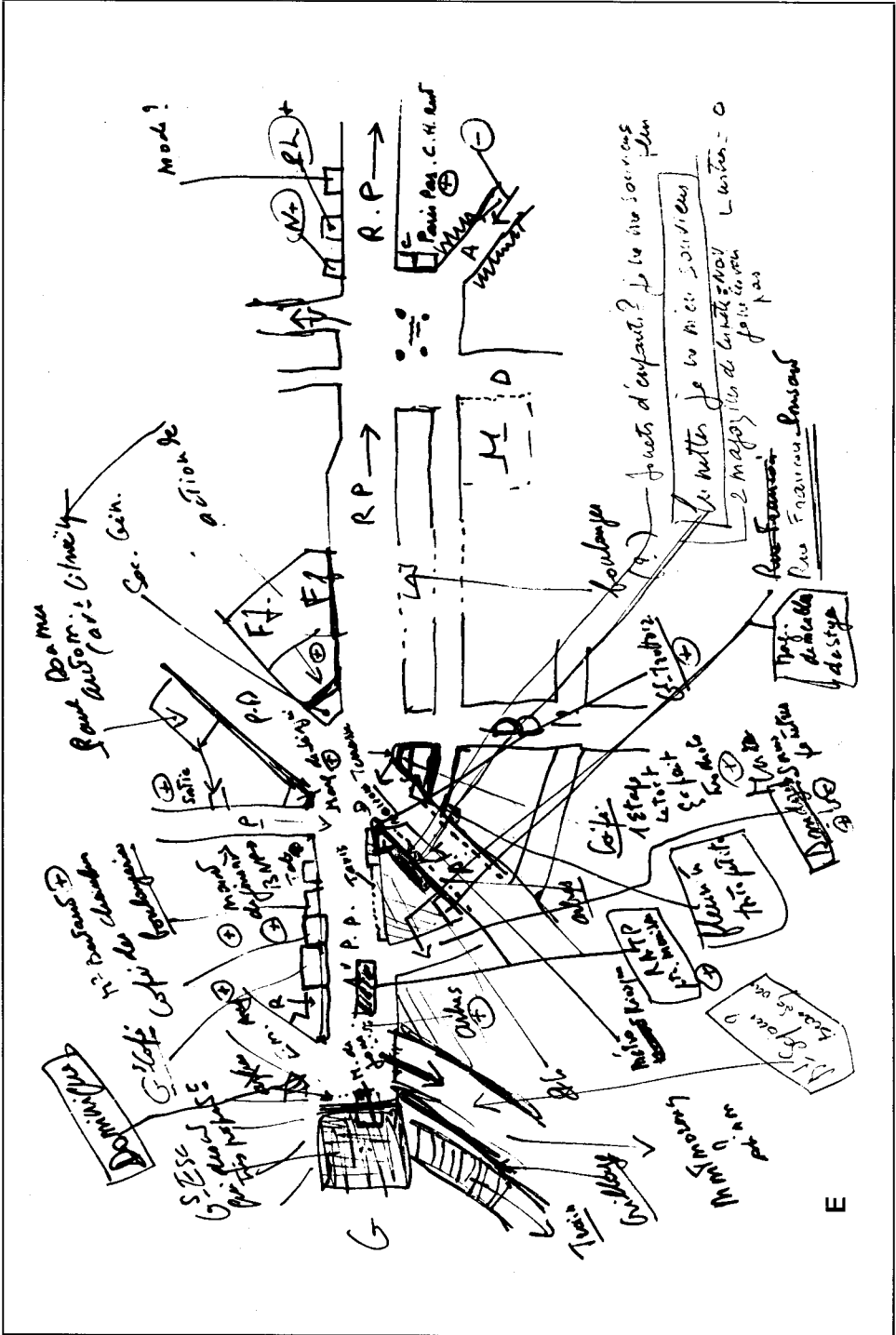
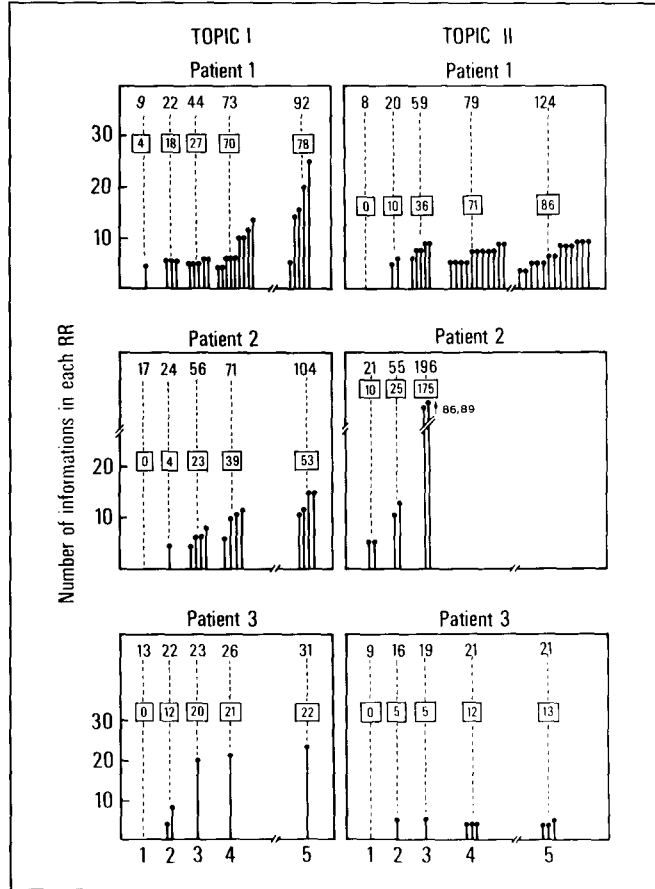


Fig. 5c

Fig. 6 – Rich responses (RR) (4 or more pieces of information). Each RR is represented in each session by a line whose height is proportional to the number of informations it contains. Ordinate: the number of pieces of information given in RR is recorded in a square and the patient's total score is reported above it. The difference between them corresponds to the number of pieces of information given by short responses (1 to 3 pieces of information).



Scoring

Three categories of answers were identified and scored. (1) *True information*: information was considered true when it was given by both the patient and her control. On some occasions, the truth was checked by consulting related maps and/or by personally checking on the premises (especially for Topics I and II). (2) *Errors*: a) true information misplaced on the map e. g. on the opposite side of the right street or on a wrong street; b) true information misplaced in time, e. g. on evening instead of morning. (3) *Confabulation*: description of places or facts that were nonexistent or unrelated to the topic, such as information belonging to another city or event(s) that had occurred during another period than the investigated day of life. Every item of true information, error and confabulation was given one point and they were separately computed for each session and each patient. To give different marks to each piece of information according to its "importance" was not possible, as "importance" depends on too many personal factors. For instance, the localization of the railway station and of the church or the description of some shops in the market or the color of the football team have more or less subjective value for each other; another example: in the last sessions, the questions were getting more and more detailed and good responses might depend on chance and on the cultural knowledge of the patient. Finally, for Topic III, giving marks for the emotional impact of information or events could not be done on an objective basis.

Answers including 4 or more pieces of information were identified and labelled as "rich responses" (RR). For each of them, the number of the piece of information was counted.

RESULTS

The cooperation of the 3 patients was excellent. They worked hard during the sessions, enjoyed the testing procedure and, at the end of each session, were not tired. For all 3 patients, remote recall dramatically increased for Topics I and II, but not for Topic III.

Topics I and II (Figures 4, 5). The patients' initial responses were poor but they gradually became longer and richer from session to session. The data recalled in a session were always recalled in the next one. The analysis of patients' recollections showed the following steps. (1) An improvement was observed already during the second session and increased in the following sessions, almost reaching the control's performance. It remained stable or was still increasing in the fifth session (Figures 4, 5). Approximative localizations were scarce and later corrected. (2) The improvement also concerned the organization of data: from some isolated data to "nested structures" or patterns with outlines followed by details (James, 1890; Neisser, 1986). (3) The new data were based on several data given in the preceding session and in areas in which the patient had previously no recollection. The flow of new pieces of information was fluent, with abundance of details, each one leading to another. (4) The visuospatial schema in which information was framed was instrumental to favour the recall of many autobiographical memories in much the same way as it did in the controls. (5) The patients never observed that they were undergoing the same testing, while the two controls submitted to a second interview were constantly embarrassed by the recollection of the previous one. (6) The recall improvement was specific to the studied topics since, late during the procedure, patients questioned on some others familiar topics gave the same kind of poor responses that they had given in the first session.

The 5th session showed the persistence of recall improvement. Because this was a "check" session, its results were not taken into account in calculations. This session of Topic II was omitted in patient 2, because she had already attained an almost perfect performance in the third session.

The number of RR increased from session to session (Figure 6). The information conveyed initially in short answers developed later in longer RR sentences. By the end of the test, most pieces of information were included in RRs. Sometimes, only 2 or 3 very long RRs encompassed the information given previously in separate RRs. The total number of responses increased because there were more questions on details needing short answers with 1 or 2 pieces of information (e. g. after patient 1 said that "Saint-Radegonde has a beautiful style", she was asked "What style?" A question that was answered with a single word "Roman").

Only patient 3 made errors. Confabulation was not observed in any patient.

Topic III (Figure 7). Improvement in the autobiographical recall was poor to nil. The responses were generally phrased in the same way across all sessions. Patient 1 made many confabulations which remained unchanged from session to session and were often included in an apparently coherent story (she did not attend the fifth session). Patient 2 made no errors. Patient 3 had no recollection.

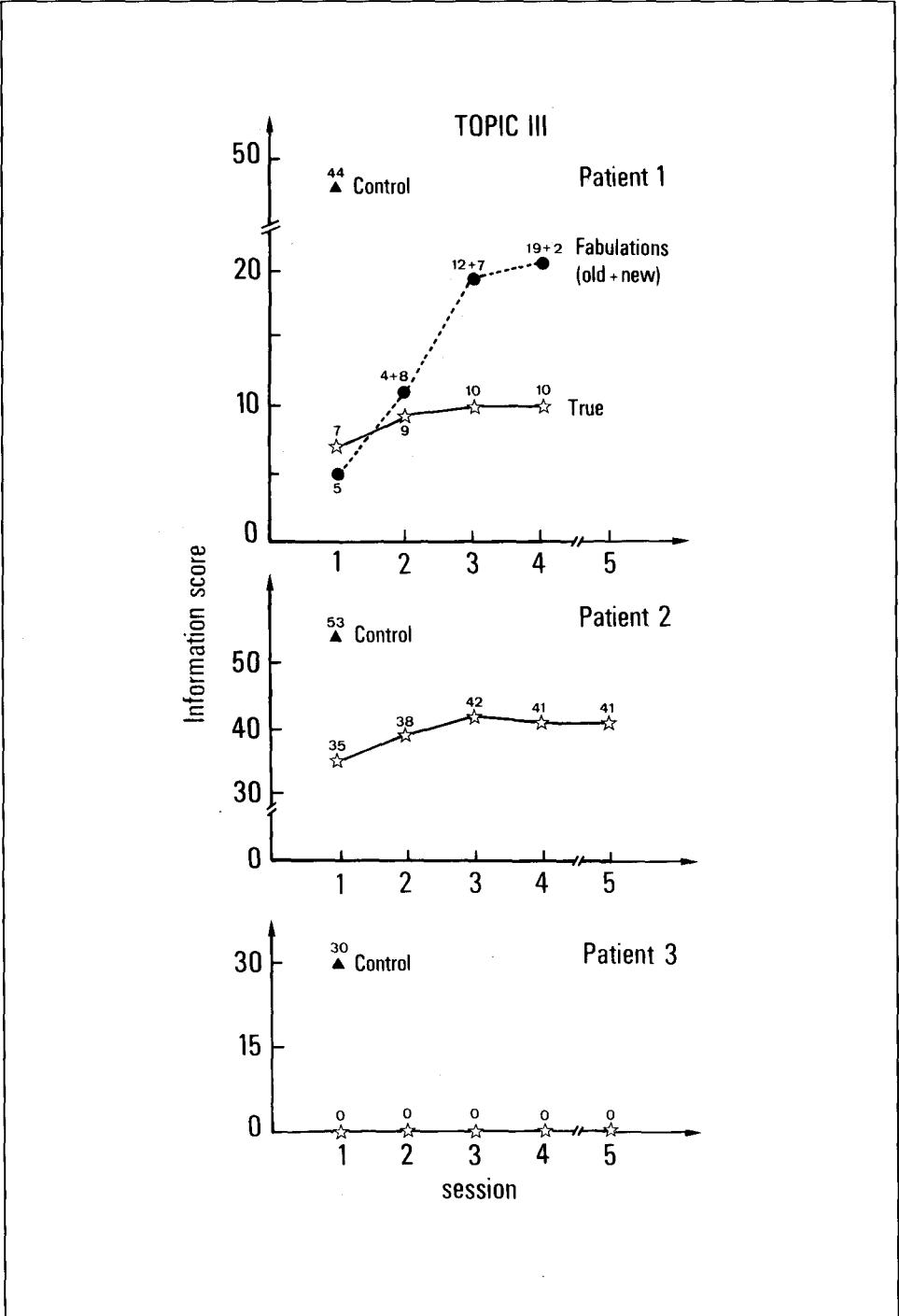


Fig. 7 - Results. Topic III (a day of one's life). The information scores improved little (patient 1) or did not improve from one session to the next (patient 2 and 3). Confabulation was abundant in patient 1.

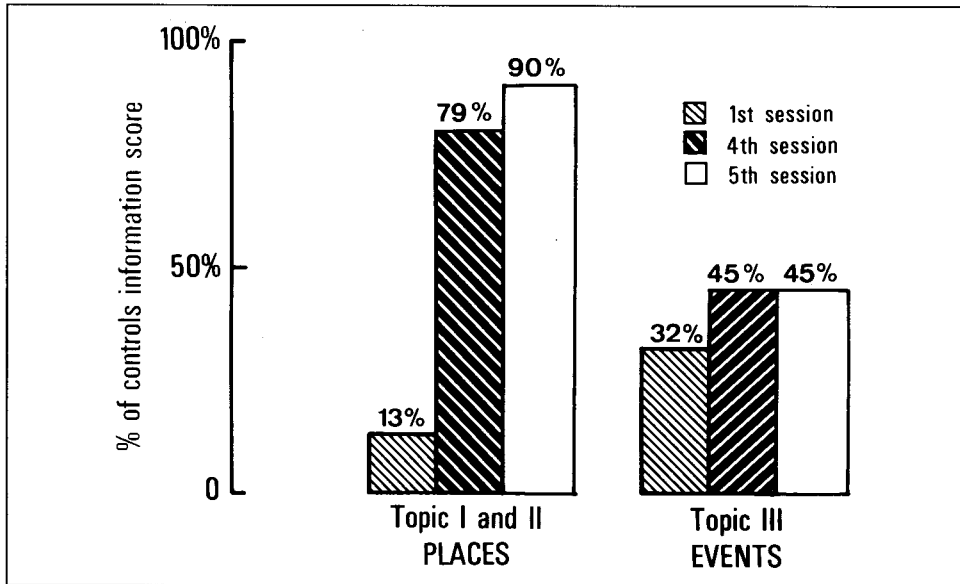


Fig. 8 – The 3 patients' cumulative data in the first, fourth and last sessions for Topics I+II, and for Topic III compared with the normal subjects' scores.

Control of AA

The control of AA yielded similar results: none of the patients could recall either the previous session(s) nor its components (Figure 2). Only at the beginning of the 4th session did the patients begin to recognize the topics when given a multiple choice list, and, at the end of the same session, they were able to spontaneously recognize on a multiple choice list a few pieces of information about that session. Before the 5th session, they remembered the topics investigated in the previous session(s), but not their details. After this session, they easily remembered the topics and more or less details of the session itself.

Statistical Comparisons

The comparison (Student's one-tailed t test) of the first and last session's results, standardized by the respective controls scores, showed a significant difference for Topic I ($t=3.99$, $p\leq.05$) and for Topic II ($t=3.44$, $p\leq.05$). Cumulative scores (the 3 patients) for the first, fourth and the last session for Topics I+II (only the first and the third in patient 2, Topic II) and for Topic III were calculated. The differences between the patients scores and the cumulative controls scores were significant: $p\leq.05$, Mann-Whitney U test (Figure 8).

DISCUSSION

The strict observance of the procedure permitted the avoidance of any bias in studying the recall. However one point is to be mentioned for its methodol-

ogical interest: many confabulations observed in Topic III for patient 1 remained unchanged from session to session giving the appearance of a coherent story (see Milner and Petrides, 1984; Damasio et al., 1985); consequently, coherence and persistence of information are not, here, evidence of the validity of that information, contrary to what has been proposed (Erdely and Kleinbard, 1978; Kihlstrom, 1984; Baddeley and Wilson, 1986).

The remarkable similarity in the evolution of the recall improvement for Topics I and II and its absence for Topic III lead to 2 main questions: (1) what is the nature of the lasting unconscious process of recall for Topic I and II? (2) What are the factor(s) leading to this difference?

Topics I and II

The kind of enrichment described above shows that the memory items were not lost but only inaccessible. Because of the presence of AA, we maintain that the retrieval activity was unconscious, and not due to conscious internal review. Moreover the recall improvement was specific for the studied topics and therefore can not be explained by a general activation for the recall processes induced by the specific interviews. To our knowledge, such an experimental demonstration of the role of unconscious activity has never been achieved. It can explain the so-called spontaneous retrieval after memory block in normal subjects, which is commonplace, especially in old age. The hypothesis of an unconscious activation is consistent with current knowledge in the neuropsychology of normal subjects (Marslen-Wilson and Teuber, 1975; Reason and Lucas, 1984; Kihlstrom, 1984; Baddeley, Lewis, Eldridge et al., 1984; Newman, Weingartner, Smallberg et al., 1984; Neisser, 1986).

The question arises as to the role of the memory activating systems, principally the HMT system, in the reactivation of the specific cortical patterns of long-term traces memories. We would suggest that in our patients the memory activating systems, though damaged, were responsible of this activation. The HMT system is thought to be a nonspecific activator of the structural changes in the cortical neurons (Symonds, 1966). It could also be the activator of the recall of the cortical long-lasting memory traces. In transient global amnesia (TGA), the classical model of the amnesic syndrome, RA is massive during the accident, but shrinks to a short persistent amnesic lacuna after the episode (Fisher and Adams, 1964; Lhermitte and Signoret, 1976). This suggests that a functional disturbance of the HMT system blocks both the processes of recording and recall. Animal experiments have shown that hippocampal long-term potentiation could be the electrical manifestation of an activation mechanism, in both formation and retrieval of long-term memory traces (Bliss and Lomo, 1973; Bliss and Dolphin, 1982; Berger, 1984; Racine and Kairiss, 1987). Other activating systems such as the reticular system can also contribute to recall processes but this is difficult to establish in human, since cerebral lesions are never strictly limited to the HMT system.

It could seem contradictory to consider that the patients were amnesic because of the HMT lesions and, meanwhile, that the enrichment of memories was

due to the activity of this system. However lesions of the HMT system do not mean a complete destruction and, in patients 1 and 2, a partial lesion could have disturbed but not entirely suppressed HMT activity. In patient 3 the poor performance was consistent with severe lesions of the hippocampi, which had probably almost destroyed the HMT system. In any case, these interpretations imply normal activities of the cerebral cortex (in another study, Alzheimer patients submitted to the same procedure did not show any improvement of their recall, which is according to the present data).

An alternative explanation would be that the patient developed a better strategy of search "or internal retrieval", in a psychological sense, during the sessions. However this hypothesis does not fit with the observed facts, because: (1) the "visuospatial strategy" on the maps was normal; (2) the patients behaved as if they had more and more memories from the first to the last session; in each session the new memories were given spontaneously in clusters without special search; (3) the emergence of a new strategy was not observed during the test.

The results of this experiment may suggest a new method of rehabilitation. None of the 3 patients improved with the traditional verbal rehabilitation procedures. Patient 2, aware of her improvement, refused to continue the classical rehabilitation and contrived to adopt the same method for learning: each day she wrote all her spontaneous memories and events and, at night, she read her notes and thought over them. She stated: "So I've rebuilt all my worlds". For 5 years, we have used a technique of rehabilitation using these principles and it has been more successful than the classical methods. Of course, it is very likely that the "relearning" is better for semantic acquisitions than for episodic memories (Tulving, Schacter, Mc Lachlan et al., 1988).

Topic III

The absence of improvement in recall shown by all patients (Figure 7) could be accounted for by the nature of the topic. The memories of Topics I and II were retrieved because they came from the semantic store (Bahrick, 1983; Bartram and Smith, 1984), and those of Topic III were not, because they came from the episodic store (Wood et al., 1982; Cermak, 1984; Tulving, 1984). The amnesia of AS often involves episodic learning, allowing retrieval from the almost intact semantic store (Kinsbourne and Wood, 1975; Schacter and Tulving, 1982; Tulving et al., 1988). Shifts exist between episodic and semantic memory. In particular, numerous self-repetitions of a past event lead to the learning of a story, that then belongs to semantic memory (Cermak, 1984). Similarly, "Some autobiographical memory traces lose their contextual dependence when often spontaneously recollected and acquire the schematic features and hierarchical organization of semantic knowledge" (Dall'Ora, Della Salla and Spinnler, 1989). This was observed in patients 1 and 2 in whom some of the few items of true autobiographical information were similarly phrased in each session, suggesting rehearsal through frequent recounting. Semantic and episodic memory can be considered as two independent systems (Tulving and Thompson, 1973, Tulving, 1984) and they may have discrete anatomical substrata with ammo-

nic diencephalic structures subserving episodic processing of information, and neocortical associative areas subserving semantic processing (Weingartner et al., 1983), but a discussion of this topic is outside the scope of the present paper.

The visual information conveyed by the drawings in Topics I and II (Figures 3 and 5) could facilitate the process of visual representation, and thus improve the process of remembering (Erdely and Kleinbard, 1978). In Topic III, however, only verbal and internal stimuli are available to activate the recall. Their neurophysiological significance was quite different from that of visual stimuli and a good example of this was found in patient 1: confabulations were absent from her autobiographical memories recalled in Topics I and II, but were abundant in Topic III.

As stated above, the neurophysiological conditions for the mnemonic activation for a day in one's life are quite different from those for places, unless the often recalled events become familiar stories. We posit that each of the moments of a life corresponds to specific activated patterns which disappear leaving place to the next ones. To recall past events, specific cortical patterns must be reactivated. Multisensorial cues to information are more efficient than purely verbal ones. Common experience suggests a model of this when one has forgotten where he had just put an object, for instance a key, and is looking for it. The key will not be found if the subject enumerates verbally all its possible locations. It will be found, often easily, if one goes back to the place where he was prior to losing track of it and repeats one's subsequent actions. Thus the specific cerebral patterns can be reactivated by the previous external and internal successive stimuli specific to the moment and the environment. Contextual cues are probably one of a number of factors making an important contribution to the retrieval of remote memories. Amongst them, verbal stimuli are not the most effective, while language is the only way to communicate autobiographical memories that have been recalled. In normal subjects, other cultural facts could illustrate the role of some non-verbal cues. Sensory memory shows how powerful a single but specific sensory stimulus can be in recalling a moment of the past. Famous examples have been provided by writers: in France, Balzac, Fromentin and Proust. The episode of "la petite madeleine" in Proust's "Remembrance of Things Past" is the best known. In "Swann's Way", the narrator is unable to recall events from his childhood, but after tasting the piece of cake, the "madeleine", he relates: "And suddenly the memory revealed itself (...) and as soon as I had recognized the taste of the piece of madeleine soaked in her decoction of lime-blossom, which my aunt used to give me (...) immediately the old grey house upon the street, where her room was, rose up like a stage set (...) and with the house the town, from morning to night and in all weathers, the square where I used to be sent before lunch, the streets along which I used to run errands, the country roads we took when the weather was fine (...) so in that moment all the flowers in our garden and M. Swann's park, and the water-lilies on the Vivonne and the good folk of the village and their little dwellings and the parish church and the whole of Combray and its surroundings, taking shape and solidity, sprang into being, town and gardens alike, from my cup of tea" (Proust, 1954). The activating stimulus in this story was non verbal. Proust used language only to relate the story for himself and others.

The unconscious activity demonstrated in this study concerned recall. In our opinion, its investigation could be a step towards an understanding of more complex brain operations. The same phenomena are commonly observed by cross-word puzzle addicts, unable to work a puzzle through in the morning but finishing it off successfully, almost automatically, in the evening. It is well documented in accounts of sudden resolutions of mental problems. Such unconscious processing probably also plays a part at the highest level of human brain activity in the processes of logical deduction and induction, such as in Archimede's famous "Eureka". More precise examples were given by Henri Poincaré (1947), a French mathematician, and by Einstein (1979), Loewy (1960) and Jacob (1986) who have reported the sudden emergence of the new idea which was the key to their discoveries, while thinking about something quite different.

ABSTRACT

The sudden resurgence of precise information some time after the failure of its recall (memory block) suggests the intervention of unconscious processes. In normal subjects the experimental demonstration of such processes meets with methodological snags. They are avoided in patients with a pure amnesic syndrome because retrograde amnesia produces many instances of missing memories, while anterograde amnesia prevents the patient from consciously thinking about it.

Three patients with a pure amnesic syndrome were submitted to 4 interviews over 12 days on 3 topics concerning places and itineraries that were very familiar before the disease, and a shocking event of their life. Retrieved memories were compared to those of normal matched subjects. The results showed a dramatic increase for memories of places and itineraries over sessions, and the absence of improvement of autobiographical memories. These findings underline the role of the activation of unconscious processes in recall and the different status of semantic and episodic memory.

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