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PERSISTENT ANTEROGRADE AMNESIA AFTER STAB WOUND OF THE BASAL BRAIN*

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Abstract—A case of anterograde amnesia is described in which the memory disorder resulted from a stab wound of the basal brain, a fencing foil having entered the brain through the right nostril, taking a slightly oblique course to the left. Follow-up studies over seven years revealed a persistent paralysis of upward gaze, as the only definite neurologic sign, together with an anterograde amnesia in which verbal material was more affected than nonverbal. Perception and vigilance were intact. There were no seizures or seizure-equivalents, and in this respect the patient's condition differed from that of H.M., the original case of anterograde amnesia after bilateral hippocampectomy described by SCOVILLE and MILNER. The stab wound in the present case appears to have involved the rostral midbrain. It is therefore of particular interest that the anterograde amnesia was combined with impotence and profound unresponsiveness to pain.

DISORDERS of memory following trauma to the human brain are notoriously frequent, but the majority of these cases are characterized by massive or diffuse cerebral damage, and the amnesia itself appears within a context of other disturbances, in which disorders of vigilance and perception play a special role. In fact, attempts have often been made to interpret the amnestic syndrome as a mere consequence of those other changes with which it tends to be associated; i.e. lack of comprehension of ongoing events producing the failure of more permanent registration.

Such interpretations of amnesia as a secondary effect, however, become sharply limited as soon as one considers instances of relatively selective memory disorders after circumscribed ablations of cerebral tissue, as in the prototype case of SCOVILLE and MILNER [31], where bilateral removals from the hippocampal zone, offered for relief of intractable epilepsy, resulted in an anterograde amnesia, which has lasted now, with only slight improvement, for nearly fifteen years. Extensive studies (the most recent ones described

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elsewhere in this issue) have made it clear that the perceptual disorders in that case were insufficient to account for the much more severe disturbances of long-term registration.

Because of the importance of such instances for any theory of memory, a somewhat similar case of selective anterograde amnesia is here reported. The initial state resembled that of H.M. [31], although the memory loss became less severe with time, leaving the patient with a residual syndrome in which disorders of verbal memory were predominant. At no time was there any epilepsy, nor any trouble of perception or vigilance. The case was studied in direct comparison with H.M., often with identical experimental methods. Accordingly, our report will focus on the similarities and differences which this comparison of the two cases has disclosed. It will be apparent that the new case can supplement certain lessons drawn from H.M.

CASE REPORT

N.A. (born July 9, 1938), a young American airman, was injured on December 15, 1960, while stationed at the Azores. The injury resulted from a mock duel with another serviceman, when a miniature fencing foil entered the patient's right nostril and punctured the base of the brain, after taking an obliquely upward course, slightly to the left.

1. *Early course after injury*

According to the service medical records, the immediate effect was not unconsciousness, but profound lethargy. There was moderate bleeding from the right nostril; the pupils were maximally constricted and fixed to light and accommodation. There was a convergent squint, and a fine rotatory nystagmus of the right eye. The admitting medical officer also noted a minimal right hemiparesis, which could not be demonstrated a day later, nor, for that matter, at any time thereafter. Nevertheless, this initial asymmetry of motor involvement is consistent with greater damage on the left side of the brain.

According to the records from that hospital, the patient was still confused and disoriented on the second day after injury, but responded to commands. No sensory losses were demonstrable, then or later. There was a spontaneous pneumoencephalogram with a small bone chip visualized in the right sphenoid sinus.

For the first three days, the patient had a fluctuating temperature and made continual chewing movements. The pupils remained fixed to light and accommodation, and there was complete paralysis of upward gaze. Speech was described as well-articulated but irrelevant and confused. From the fourth day onward, rhinorrhea was noted, which continued intermittently until two weeks after the accident, when a frontal craniotomy was performed; a dural tear was found overlying the tuberculum sellae and was repaired.

For the first few days after operation, the patient's state of consciousness varied from alert to deeply lethargic, but by the end of the first month after the injury, he was considered to be fully alert, his speech was deemed relevant, and his comprehension intact. However, there was said to be profound loss of recent memory; the pupils were still unresponsive to light and accommodation, and there was the previously noted paralysis of upward gaze. This Parinaud syndrome, together with a defect in retaining ongoing events, were reported consistently as the only obvious sequelae of the accident demonstrable on neurologic examination.

Initial retrograde amnesia. The examiners (including H.V., who saw the patient at the Philadelphia Naval Hospital) noted that at first he seemed to be unable to recall any significant personal, national or international events for the two years preceding the accident, but this extensive retrograde amnesia appeared to shrink *pari passu* with improvement in his posttraumatic state. Two-and-a-half years after the accident, the retrograde amnesia was said to involve a span of perhaps two weeks immediately preceding the injury, but the exact extent of this retrograde loss was (and remains) impossible to determine.

Early stages in anterograde amnesia. During this early period of convalescence (for the first six to eight months after the accident), the patient's recall of day-to-day events was described as extremely poor, but "occasionally some items sprang forth uncontrollably; he suddenly recalled something he seemed to have no business recalling." His physicians thus gained the impression that his memory was patchy: he appeared to have difficulty in calling up at will many things that at other times emerged spontaneously.

Mood; awareness of illness. At this time N.A. impressed his examiners as "not euphoric but lacking in affect appropriate to his condition," and his behavior still fits this description. Yet ever since the early posttraumatic period he has shown full awareness of his defect: he apologizes constantly for his poor memory, but insists that he will soon get over it and resume his interrupted college education.

Psychometric data. During the one year spent in college before his entry into the Air Force and subsequent injury, the patient took a number of vocational aptitude tests. The results of these tests suggest superior mechanical aptitude and interests compatible with the patient's original ambitions of becoming an engineer.

On March 27, 1961, 3½ months after the accident, he was tested with the Wechsler Adult Intelligence Scale, obtaining a verbal intelligence quotient of 101, a performance quotient of 98, and a full-scale quotient of 99. His examiner at the Naval Hospital suggested that these results (although within the normal range) might represent a significant drop from his pre-injury level, which was estimated on the basis of his scholastic achievements as being considerably higher. In contrast, his performance on the Memory Scale [35] was grossly defective: his memory quotient was given as 64, which is considerably below his rated intelligence at that time.

2. *Subsequent clinical course*

Following his discharge from the naval hospital in August, 1961, the patient was in the care of his mother and his stepfather, who took up residence in a small coastal town not far from San Diego, California. Since his injury, he has been unable to return to any gainful employment, although his memory has continued to improve, albeit slowly.

Throughout this seven-year period, N.A. has been subjected to repeated examinations, twice in the MIT laboratories (for one week each time, in January and October, 1964), and twice on home visits (in October, 1966, and August, 1967). Improvement in his memory was noted particularly on his second admission in 1964, and has continued since, although the recovery of his verbal memory has been lagging in relation to performance on other material-specific memory tasks, producing an evident asymmetry in the residual loss. Thus, on his first visit to MIT, he failed to recognize H.V. although H.V. had cared for him at the Philadelphia Naval Hospital. On his second visit, however, he correctly stated that he had met H.L.T. the previous time (8½ months earlier), and that B.M. had not seen

him before, but he still could not produce H.L.T.'s name. Even on that second visit, he could not describe more than an isolated fragment or two in trying to relate the plot of a movie seen the night before. He complained that he forgot the story-line of television plays whenever they were interrupted by commercials. All this was in striking contrast to the patient's facility in recounting premorbid events in their proper order and in considerable detail. Thus he was able to enumerate five different addresses at which his family had lived consecutively before his injury.

As in other instances of persistent anterograde amnesia [30, 37, 38] N.A. has not been able to give any account of the early posttraumatic period, although he seems vaguely aware that he may have been in one or several hospitals, at various times, since his injury. There is thus nothing like the tendency one finds so commonly in patients who recover from a period of posttraumatic amnesia, and who insist that there was a definite moment, which they can recall, when their memory "came back," or "things became clear again." Nor does N.A. report any "islands" of memory which, again, are so typical of the more usual posttraumatic state.

Autoscopy. Nevertheless, N.A. does produce a remarkable story which he localizes subjectively in the period of his early convalescence. He tells this story in unvarying fashion, except for a different ending, whenever he is asked to comment on his hospital experience: "I think I remember a time, many times, when I used to sit in a movie theater, and there was this fellow on the screen, in the movies, with his head all bandaged, and he seemed to be in pain. I said—every time I saw him—somebody do something for him—give him a glass of water or something—and then suddenly (and here comes the variation in the end of the story)—suddenly, last night (or, at other tellings of the story: suddenly, a year ago—suddenly, last week, etc.), I realized this fellow on the screen was I."

N.A.'s mother alluded independently and spontaneously to such a form of autoscopy, when she told one of us (H.L.T.) on the second visit to the patient's home that her son used to say rather irrational things as long as 1½ years after his injury. Once, while he was resting on his bed, with his mother sitting at the side of the bed, he suddenly complained (according to his mother), "why are you paying so much attention to the fellow on the bed instead of paying attention to me?" Quite similar forms of autoscopy have been reported in cases of twilight state, in delirium, and in postencephalitic conditions [8, 12, 13, 15].

Everyday behavior

The home visits revealed that N.A. leads a rather indolent life, mowing his lawn and performing other chores around the house and garden if, and only if, he is instructed to do so ("driven to it," according to his mother). He takes long walks up and down the beach (which is within a block of their house), but apparently becomes unsure of the direction in which he would have to return to their house, unless he asks. He had tried, at the urging of one of us, to work in a local TV repair shop, but lost the job on the second day, although not for lack of the requisite mechanical skill.

According to his mother, he took up the hobby of building plane models in 1965. His first models were clumsily done, but his skill improved; at the time of our visit in 1966, several of his models were on public exhibit in San Diego.

The patient's room is extremely tidy and full of his airplane models. Apparently, he spends a good deal of time putting his room in order; once he has finished, he proceeds to tidy up the rooms of his mother and stepfather, much to their annoyance.

Unresponsiveness to pain. Numerous instances were discovered during the home visits that point to an unusual degree of pain tolerance in N.A. His mother complained that he would frequently buy himself shoes that were too small, and then wear them, oblivious of the severe blisters that formed on his feet. As another instance of unusual tolerance for pain, his mother reported that in 1966 he had found a wild seal on the beach near their house. He picked up the seal and was promptly bitten severely around the flanks; the lacerations bled profusely and required suturing. However, throughout this episode, N.A. expressed no discomfort and refused all pain-reducing medication. Nor does he complain of ordinary, everyday pain, such as headache or stomach-ache, although he sometimes tells his mother that he has hunger "pains" (presumably meaning hunger pangs), if he has not eaten for five hours or so. Even then, he does not seem distressed.

The continued tolerance of pain was underscored in a very recent report. In 1967, N.A. and his mother went on a round-the-world cruise. On this trip it was noted that he walked with his bare feet on the hot metal deck of the cruise ship, incurring burns on his soles, to the point where his fellow passengers complained of the unpleasant odor; he himself did not seem to mind.

Impotence. N.A.'s unresponsiveness to pain seems combined with an apparent loss of sexual drive. That he might be actually impotent came to our attention as follows: With some reluctance, his mother told us that her son had recently been "rushed into marriage" by a girl he had known as a fellow-student before his accident. The mother insisted that she knew for certain that her son and this girl had had frequent sexual relations while in college. The girl had persuaded N.A. (against the advice of both families) to marry her in the fall of 1965; the two young people lived at the home of the girl's parents, but seven weeks later the marriage was annulled because "it had never been consummated."

3. *Results of further tests and experimental procedures*

The patient underwent numerous laboratory procedures during his two visits to MIT. These included neurologic and EEG studies, extensive sensory and sensorimotor tests, and various perceptual and learning tasks.

Neurological examinations. Detailed neurologic testing in 1964, 1966 and 1967 revealed each time an essentially normal neurologic status, except for the continuing anterograde amnesia and the oculomotor syndrome. The latter consisted of an inability to move the eyes upward upon command, with a slight but consistent difference between the eyes, the left eye rising on effort a bit above the horizontal plane and producing a skew deviation, with a moderate vertical nystagmus, as long as the effort to look upwards was maintained. On passive forward flexion of the neck, however, the patient showed a classical doll's head phenomenon, the eyes moving promptly, if transiently, to the extreme vertical upward position. There always was binocular diplopia on attempted conjugate gaze to the right.

In contrast, the tendon reflexes were normal, although slightly more brisk on the right, while abdominal and cremasteric reflexes were diminished on that side. The right palpebral fissure was slightly narrower than the left, and there was a bare hint of a right facial weakness, of central type. There were no obvious changes in strength or tone, in any extremity. Gait and attitude were normal, and extensive (quantitative) sensory, auditory, and visual-field studies failed to disclose any abnormality in somesthesis, audition or vision. The electroencephalogram was likewise considered as completely normal, as were the patient's

computer-averaged cerebral potentials evoked by single and repeated flashes of light (H.V.). There were no signs (nor was there any history) of seizures, nor of seizure-equivalents. There were no abnormalities in the sleep-wakefulness and body-temperature cycles observed at successive three-hour intervals for three consecutive days and nights, while the patient was in the Clinical Research Center.

Amytal interview. Because of the unusual features of this case, N.A. was interviewed in 1964 under Sodium Amytal. As in case P.B. of PENFIELD and MILNER [27], his memory disorder was enhanced rather than diminished, while under the influence of the drug.

Standard tests of intelligence and memory. A follow-up examination with the Wechsler Scale (carried out at MIT by Dr. Suzanne Corkin on October 20, 1964) gave N.A. a full-scale intelligence quotient of 118, with a verbal quotient of 113 and a performance quotient of 120. It thus appears that ordinary test-intelligence had recovered sufficiently to parallel the patient's estimated pre-injury level. A similar pattern of initial fall and subsequent rise was seen on successive testing with the Wechsler Memory Scale. In October, 1964, N.A. achieved a memory quotient of 94, which represents a marked improvement over the values of 64 and 72 obtained in March, 1961 and May, 1962, respectively. However, the memory quotient was still clearly inferior to the intelligence quotient.

Special perceptual and perceptual-motor tests. N.A. excelled most normal subjects on a variety of perceptual tasks, which included tachistoscopy and measures of visual search. He showed normal fushion-thresholds for flickering light, and, according to Dr. Peter Schiller, normal "metacontrast"; i.e. normal interaction between stimuli when two visual patterns are exposed briefly in succession, with varying inter-stimulus intervals. He also did as well as normal control subjects in the adaptation of visually-guided reaching, for targets viewed through distorting and displacing (i.e. prismatic) spectacles. Like H.M., he showed normal learning of a mirror-drawing task, when tested over three consecutive days.

Hidden-figures test. The patient was given the hidden-figures test, in which certain geometric patterns have to be traced within a welter of embedding and overlapping lines (modified GOTTSCHALDT figures [6]). This task had previously been found to be difficult for men with penetrating trauma of the cerebral convexity, irrespective of the lobe injured [33]; (see Fig. 1). Similar results were obtained later by VIGNOLO [34] for cases of vascular disease or brain tumor, and severe deficit on the task has been reported by TALLAND [32] for patients with amnesia arising in the context of Korsakov's disease. As Fig. 1 shows, our patient, N.A., not only surpassed the group averages of the previously-studied traumatic cases, but also surpassed most of our normal control subjects, obtaining a score of 43. In contrast, H.M., who tends to work slowly on most tests, earned the much lower score of 23 on the same task. N.A. obviously enjoyed the test, announcing that it was easy. When confronted with the same test on the following day, he obtained the same high score, though taking an even shorter time, but denied that he had ever done or seen the test before.

Sorting test. We had a similar experience on administering the Wisconsin version [7] of WEIGL's [36] well-known sorting test. Here the patient readily indicated that he understood the instructions, and, like H.M., sorted the cards correctly according to the three principles of color, form and number, shifting from one category to another as required by the structure of the task. His performance was superior to that of most of our control subjects, as he achieved runs of 10 successive correct responses to each of the 3 categories

twice in 93 trials. At the end, he explained the principles accurately. Two hours later, however, he did not seem to remember the test, yet he completed it in fewer trials the following day, although stating flatly that he had never encountered the material before.

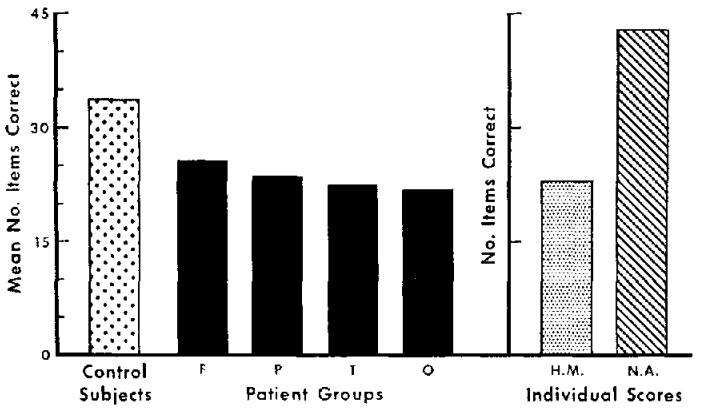

FIG. 1. Mean scores on hidden-figure test (modified Gottschaldt figures), for 43 normal control subjects, and for groups of cases with penetrating missile wounds of the cerebral convexity, viz. 32 frontal (F), 26 parietal (P), 23 temporal (T), and 28 occipital (O) penetrations (based on TEUBER and WEINSTEIN [33]). Scores for patient H.M., the case of bilateral hippocampectomy, and for N.A., the case of stab wound of the basal brain, are added for comparison. H.M.'s performance is impaired; N.A.'s performance is superior.

Formal tests of memory defect. All these instances of integrity of performance stand in clear contrast to the patient's continuing difficulty in acquiring new information. This amnestic disorder was explored further by B.M. in 1964. The tests used were those developed in Montreal for the study of "material-specific" memory loss after unilateral temporal-lobe removals, right and left [18, 21], as well as for assessing the more severe amnesias resulting from bilateral mesial temporal-lobe damage.

Maze-learning. On a visually-guided stepping-stone maze, originally administered to H.M. [16, 17], N.A. took nearly twice as many trials to learn the correct path as the slowest learner in Milner's normal control group. He required 47 trials and made 188 errors before reaching the criterion of 3 successive errorless runs. The normal control group averaged 17 trials and 92 errors. Figure 2 shows N.A.'s learning curve plotted on the same scale as that of S.D., the slowest normal subject; S.D. reached criterion in 27 trials, with 175 errors.

N.A.'s impaired performance on this task becomes more notable if one realizes that, like H.M., he shows superior performance on spatial tasks that do not require the storage of new information; for example, he is good at copying designs with blocks. Nor can his slow maze-learning be attributed to his verbal-memory defect, since patients tested two weeks after left anterior temporal lobectomy show normal maze-learning, despite their dysphasia and trouble with verbal recall.

N.A. was subsequently trained, by Dr. Suzanne Corkin, on a tactually-guided alley-maze. He reached criterion in 46 trials with 221 errors, in comparison with mean values of roughly 30 trials and 90 errors for her normal control group [5]. Figure 3 shows N.A.'s learning curve for the tactual maze, together with the curves for the two least efficient

normal subjects, one of whom (S.D.) was also the slowest learner among the normal subjects tested on the visual maze (Fig. 2).

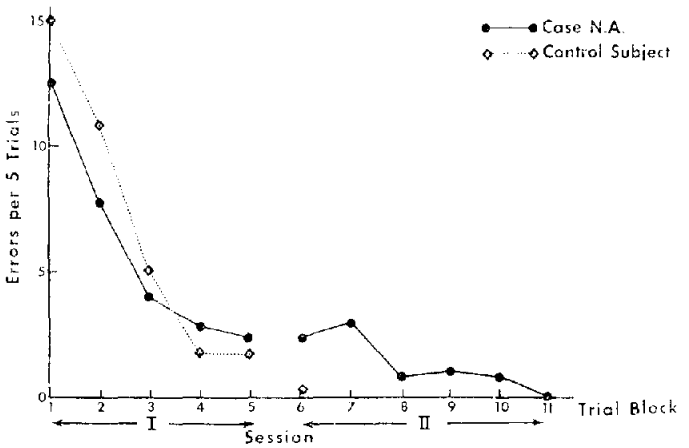

FIG. 2. Visual maze [17]: learning curve for patient N.A., compared with the curve for the slowest normal control subject (S.D.). N.A. took longer in mastering the maze. Patient H.M., however, did not learn the maze at all.

N.A.'s tactual-maze performance can be considered moderately impaired, and again the deficit cannot be regarded as secondary to the verbal memory difficulty, because dysphasic patients with recent left temporal lobectomies and pronounced verbal memory disturbance learn the tactual maze at a normal rate. N.A.'s above-average intelligence and superior spatial ability would lead one to predict a more efficient performance on this task. It is clear, however, that neither on the tactual nor the visual maze does his learning impairment approach that of H.M., who showed no diminution of error-score on either task over several days of testing.

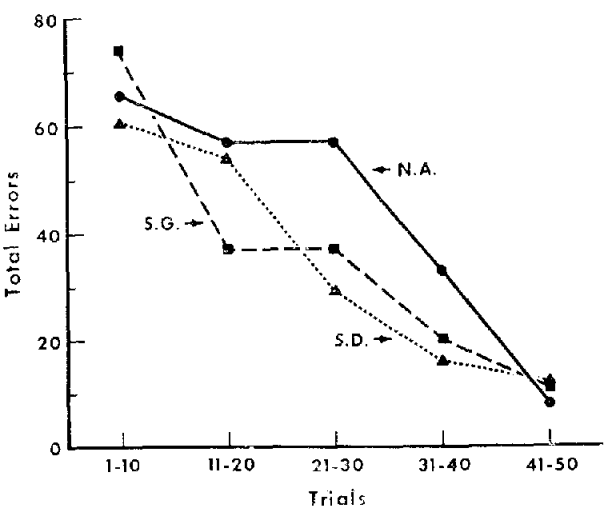

FIG. 3. Tactual maze [5]: learning curve for N.A., compared with curves for S.G. and S.D., the two slowest learners in the normal control group. (Data supplied by Dr. Suzanne Corkin).

Delayed visual reproduction (*Rey-Osterrieth figure*). That N.A. has a relatively mild but persistent defect in the memorization of nonverbal material was still evident in 1966, when he was tested with the familiar Rey-Osterrieth drawing shown in Fig. 4 [29, 24].

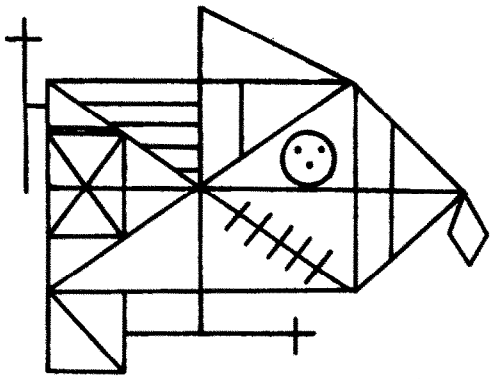

FIG. 4. Rey-Osterrieth figure [29, 24].

N.A. was first asked to copy this complex design; then, about 40 minutes later, and without forewarning, he was asked to draw the figure again, as accurately as he could, from memory. His copy and the delayed reproduction are both shown in Fig. 5.

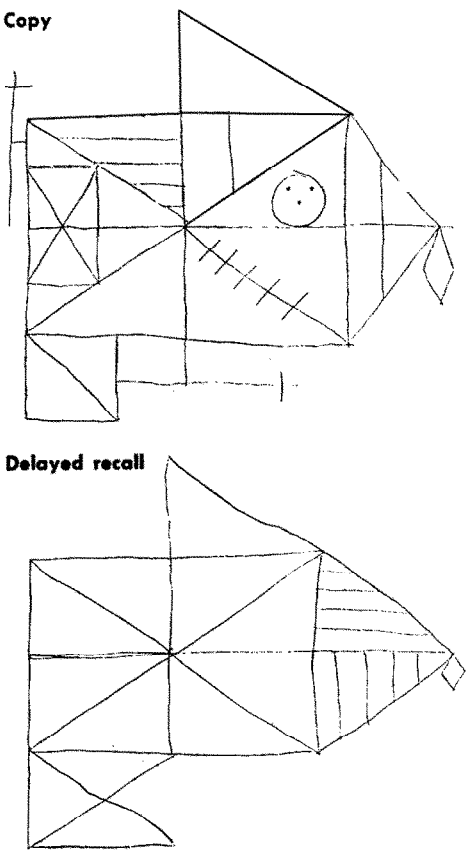

FIG. 5. Performance of patient N.A. on the Rey-Osterrieth test. Above, the patient's copy of the model; below, his drawing from recall, 40 minutes later.

This visual, nonverbal, memory task is one on which patients with left temporal-lobe lesions in the dominant hemisphere for speech show no impairment, in contrast to their marked difficulty with verbal memory tests. Right temporal lobectomy, conversely, produces a slight but significant defect in copying the Rey figure and a pronounced accentuation of the defect on delayed recall (TAYLOR, in preparation), but no verbal memory defect. Table 1 permits a comparison of N.A.'s scores with those of the left and right temporal-

Table 1. Reproduction of Rey-Osterrieth figure by N.A. and by patients tested at least one year after left or right temporal lobectomy* (Maximum score: 36)

	Copy		Delayed reproduction		Loss (%)	
N.A.	32		17		47	
	Mean	Range	Mean	Range	Mean	Range
Left temporal (N=19)	33.1	30–35	21.2	14.5–28.0	36	20–54
Right temporal (N=26)	30.0	22–34	14.2	6.0–24.5	53	24–80

* These scores were obtained by L. Taylor in Montreal.

lobe groups respectively. On copying, N.A. shows no abnormality, his score of 32 being close to the mean score for the left temporal group; but the loss on delayed recall is quite striking, especially if one looks at this loss as yet another instance of the discrepancy between this patient's intact spatial and constructive abilities and his impaired capacity for storing new information.

Continuous recognition tests (recurring visual stimuli). A more meaningful picture of the quality of N.A.'s memory disorder comes from two continuous recognition tasks, which were given in October, 1964, at about the same time as the maze-learning tasks previously described.

One recognition task involved recurring "nonsense" figures; with this task, KIMURA [10] has shown convincingly that right temporal-lobe excisions, involving inferior lateral, as well as mesial (hippocampal) cortex, are followed by deficits in recognition that do not appear after similar removals from the left hemisphere. In contrast, with an analogous task involving words, nonsense syllables and three-digit numbers, specific deficits in recognition appear after left temporal-lobe removals, even in the absence of clinically detectable dysphasia, whereas normal scores are obtained by the right temporal-lobe group [19].

For the nonverbal task, 160 cards are used. The patient is shown one card at a time, for 3 sec each; the card bears either a nonsense design or some unfamiliar geometric figure, making it difficult for the patient to use verbal labels in committing the pattern to memory. The test is presented in successive blocks of 20 cards; in each block 8 figures recur, while the rest occur only once. The task is to recognize the recurring figures by saying "yes" when they occur, and "no" when the figure shown is in fact novel. On the

first block of 20 test cards normal subjects make numerous errors, but their performance improves markedly on the second block of cards, and levels off thereafter. The verbal form of the test has analogous structure, permitting a similar measure of improvement over the series of trials.

Figure 6 shows N.A.'s performance on both the nonverbal and the verbal forms of this test, as compared with the mean scores achieved by normal control subjects, and by

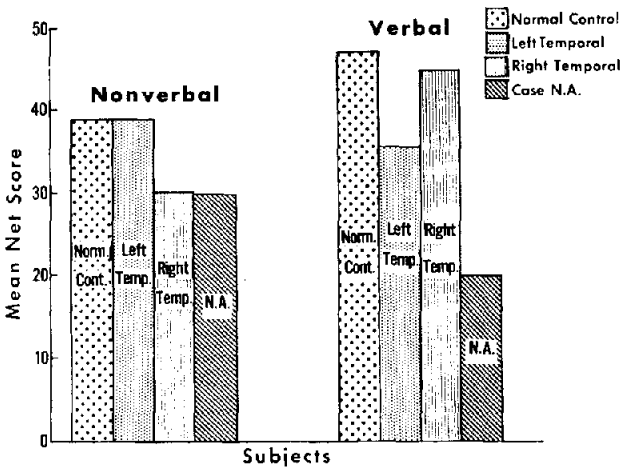

FIG. 6. Performance of patient N.A. on two visual recognition tasks (recurring nonsense figures, and recurring words, nonsense syllables, and numbers) compared with that of normal control subjects and of groups of patients with removals from left and right temporal lobes, respectively [19]. Note that N.A.'s performance is similar to that of the right temporal-lobe group on the nonverbal task (both being impaired) but is inferior to that of all other groups on the verbal task.

groups of patients tested one or more years after left or right temporal-lobe resections, respectively. It is evident that the tasks bring out material-specific memory defects [18]: left temporal-lobe removals produce persistent deficits on the verbal form of the test but not on the nonverbal; right temporal-lobe removals have the reverse effect. As Fig. 6 shows, N.A. does as poorly on the nonverbal task as the patients with right temporal-lobe resections; on the verbal task his deficit is still more conspicuous, his performance being inferior to that of both unilateral temporal-lobe groups. His nonverbal recognition-defect is thus seen to be congruent with the mild but unequivocal impairment in maze learning, both visual and tactual, already noted. His verbal recognition-defect is far more striking; in fact, it is more severe than that shown by dysphasic patients in the early postoperative period after a left temporal lobectomy. Yet N.A.'s verbal trouble seems to be specific to the sphere of memory; there is no clinical evidence of dysphasia, and, on a timed test of object naming [22, 23] he named all objects promptly and correctly.

Figure 7 compares N.A.'s performance on the two continuous recognition tasks with that of four patients (including H.M.), all of whom had profound amnestic syndromes, which were attributable to bilateral mesial temporal-lobe damage. It is apparent that N.A.'s verbal recognition defect is as grave as that displayed by any of the patients with bilateral mesial temporal-lobe involvement. On the nonverbal task, N.A.'s deficit is seen

to be much less severe than theirs. The performance of the other amnesic patients on these two tests reflects the greater difficulty of the nonverbal task for normal subjects, as well as the relative severity of their individual memory disorders.

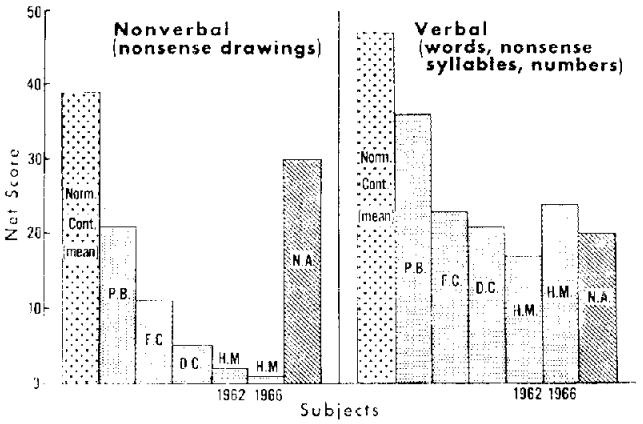

FIG. 7. Performance of amnesic patients on the two continuous visual recognition tasks. Scores for individual patients are compared with the average scores for normal control subjects. P.B. and F.C. had sustained unilateral (left) temporal lobectomies, with persisting electrographic disturbances in the right temporal lobe (i.e. on the side contralateral to the excision). D.C. (not operated upon at the Montreal Neurological Institute) was referred for study after bilateral mesial temporal-lobe resection combined with orbito-frontal undercutting [31]. H.M. (tested twice) is the case of bilateral hippocampectomy, and N.A. the case of stab wound of the basal brain. Note that N.A.'s performance on the verbal task resembles that of the other cases of amnesia, but that he surpasses them on the nonverbal task.

DISCUSSION

Our initial interest in this case was aroused by its seeming similarity to the case, H.M., of SCOVILLE and MILNER [31]. It may therefore be appropriate to review those aspects of the two cases in which they resemble each other, and those in which they differ.

Syndromes

Both N.A. and H.M. exhibit a relatively unmixed anterograde amnesia, but H.M.'s condition is obviously much more severe, with comparatively little improvement over the fourteen years of postoperative observation (although some improvement, of delayed onset, has recently been noted). In contrast, N.A.'s condition has improved considerably over the seven years since his accident. Unexpectedly, this improvement went beyond the early post-traumatic period; in fact, a rather conspicuous spurt was noted between the patient's first and second visits to the M.I.T. laboratory, 37 and 46 months, respectively, after the wounding. For this reason, the results of the special memory tests reported above (most of which were carried out from 46 months to six years after the injury) almost certainly fail to reflect the severity of the initial amnestic disorder in this case.

It is clear that N.A.'s residual amnesia shows a marked asymmetry, verbal material being more difficult for him to retain than material that cannot readily be verbalized; in this respect N.A. differs from H.M., whose amnesia was equally severe for both types of material.

Also in contrast to H.M., our patient N.A. had a normal EEG with every method of recording that was used. He has never been subject to seizures or seizure-like episodes, and he is keenly alert and attentive. He performs extremely well on a great variety of perceptual tasks, and shows no sensory or motor deficits outside the oculomotor sphere.

The integrity of N.A.'s performance in all these respects gives support to our belief that H.M.'s seizure disorder, his somatosensory deficits, and his relative slowness on certain timed tasks are merely symptoms which happen to be associated with his amnestic state but do not form its root. Perceptual difficulties are, in principle, dissociable from the memory disorder; seizures and abnormal EEG activities are not necessary for the appearance of anterograde amnesia in man.

Lesions

We must admit that the effective lesion in N.A.'s case remains a matter of surmise. The absence, within days of the trauma, of any motor or sensory disturbances, except for the persistent paralysis of upward gaze, is consistent with the belief that the puncture would have involved the superior quadrigeminal region, entering the brain from below, just to the left of the midline. In addition, the diminished pupillary reaction to light suggests some involvement of the pretectal region. The lesion may thus have been quite circumscribed, although the extent of local damage may have been increased by vascular involvement, or as a consequence of infection during the immediate post-traumatic period.

Other cases of stab wound involving the base of the brain have been reported, with dissimilar consequences depending on whether the peduncle was affected [2] or the central gray [11]. In the former case, there was unilateral (ipsilateral) ophthalmoplegia, and a massive pyramidal-tract syndrome on the contralateral side of the body, but no persistent anterograde amnesia. In the second case [11], the picture resembled that presented by N.A. in several respects: there were oculomotor abnormalities involving both eyes, some retrograde amnesia, and marked anterograde amnesia. Unfortunately, the record does not reflect on such possible associated symptoms as unresponsiveness to pain, or reduction in sexual drive.

The curious form of autoscopy reported by N.A. has been said to occur in cases of space-occupying lesions in the region of the third ventricle (craniopharyngiomas; suprasellar tumors), and a more general hallucinosis is often described as part of a peduncular syndrome [8].

Whatever the exact lesion in N.A.'s case, it is probably rather different from that of H.M., where the memory disorder appeared after bilateral hippocampectomy. The presumed difference in lesion site supports the belief that amnestic syndromes can be produced by interfering with diverse parts of a complex anatomical system [1, 30].

Nature of memory disturbance

As to the nature of the amnesia in N.A.'s case, enough has been said to underline the features which have been thoroughly described for H.M.: There is orderly retrieval of early (premorbid) material, except for the time just preceding the trauma, although the exact extent of N.A.'s residual retrograde amnesia remains in doubt. In common with H.M. and similar cases of persisting anterograde amnesia, N.A. went through a prolonged period of confusion beginning immediately after the trauma. The residual anterograde amnesia was characterized in both cases by a short-term memory that seemed more nearly intact than the capacity for long-term registration; their perceptual and intellectual capacities, apart from those requiring long-term retention of ongoing events, appeared to

be essentially preserved, producing a picture of amnesia that could not be reduced to any initial failure of categorizing the immediate experience.

Other associated symptoms may have to be studied further, in larger numbers of cases, before it can be determined whether these too are dissociable from the memory disorder. In particular, the somewhat impassive disposition noted in N.A., may be an integral part of the amnesic syndrome or a neighborhood symptom without intimate relation to the difficulties of retention. Similarly, the apparent indifference to normally painful stimuli and the marked reduction in sexual drive (actual impotence?) need to be further explored in other cases, in order to see whether one is dealing with a coincidental constellation or a necessary association of symptoms.

In attempts at interpreting the amnesic syndrome in terms of mechanism, it has at times been suggested that the brain structures which mediate the transition from short-term to long-term memory (more permanent "encoding") are identical with those involved in voluntary retrieval (deliberate recall). The suggestion is attractive, because it appears to fit certain observations on the effects of stimulation of anterior mesial brain structures in conscious man. We know, for example, that transient amnesias can sometimes be induced by stimulating the amygdala (with spread of abnormal activity to the hippocampus), these amnesias having both retrograde and anterograde components [3, 4, 14]; conversely, a forced reliving of entire scenes has been evoked in epileptic patients upon stimulating temporal neocortex [26, 28], although the hippocampus itself has usually been behaviorally silent to electrical stimulation [9, 25]; but see CHAPMAN *et al.* [4].

Unfortunately for any simplifying interpretation, retrieval of older traces is essentially normal even in such a persistent anterograde amnesia as that exhibited by H.M. It is the inability to retrieve ongoing events, beyond an initial period of retention, together with the persistent failure of access to events immediately preceding the onset of the lesion (retrograde amnesia) that need to be explained.

Beyond this, any neurologic theory of memory will have to account for the fact that feelings of familiarity can be so readily dissociated from recall of events as such, so that some things may be remembered without the slightest familiarity ("jamais vu"), or new events registered with a false but overwhelming sense of familiarity ("déjà vu")—the "mental diplopia" of Hughlings Jackson.

Lastly, in attempting to formulate a theory of memory, one must consider the fact that memory losses can be, to some extent, material-specific [18]. Appropriate techniques can demonstrate that right temporal-lobe lesions produce amnesia for certain kinds of nonverbal material, and that left temporal lesions have an equally selective effect upon memory for verbal material. N.A., whose lesion appeared to involve basal brain regions slightly to the left of the midline, soon began to show an asymmetry in the pattern of his anterograde amnesia (having greater trouble with verbal than with nonverbal material), although initially he had been almost globally amnesic. The suggestion might be made that rostral projections from the midbrain could account for the observed asymmetry. On this view, hypothetical mechanisms for long-term memory would operate from below on the differentially specialized right and left cerebral hemispheres of man.

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Résumé—Un cas d'amnésie antérograde est décrit dans lequel le trouble de la mémoire provient d'une blessure à la base du cerveau, un fleuret ayant pénétré dans le cerveau à travers la narine droite pour prendre ensuite une direction légèrement oblique vers la gauche. Une étude de ce cas poursuivie pendant 7 ans n'a révélé comme signe neurologique qu'une paralysie persistante du regard vertical, ainsi qu'une amnésie antérograde dans laquelle le matériel verbal était plus affecté que le matériel non verbal. La perception et la vigilance étaient intactes. On ne notait ni crise, ni équivalent, et à cet égard cette observation diffère de celle de H.M., le cas princeps d'amnésie antérograde après hippocampectomie bilatérale décrit par SCOVILLE et MILNER. Il semble que le fleuret ait, dans le case ici décrite, entraîné une lésion de la région prétectale. C'est pourquoi, il est d'un intérêt tout particulier de souligner qu'une impuissance et une absence de réponse à la douleur étaient associées à l'amnésie antérograde.

Zusammenfassung—Wir beschreiben einen Fall von anterograder Amnesie, in dem die Gedächtnisstörung in Folge einer Stichwunde im basalen Gehirn auftrat: ein Florett war in das rechte Nasenloch aufwärts und etwas schräg nach links eingedrungen. Nachuntersuchungen, die sich bisher auf sieben Jahre erstreckten, zeigen eine Paralyse des vertikalen Blicks nach oben, und sonst keine anderen neurologischen Symptome, ausser dem amnestischen Syndrom, das in diesem Fall mehr die verbalen als die nichtverbalen Gedächtnisleistungen beeinträchtigte. Wahrnehmung und Aufmerksamkeit waren intakt. Der Patient hatte keine epileptischen Anfälle oder epileptische Equivalente; in dieser Hinsicht war er anders als H.M., der ursprüngliche Fall von anterograder Amnesie nach doppelseitiger Abtragung der Ammonshornrinde, der von Scoville und Milner beschrieben wurde. Im gegenwärtigen Falle schien die Stichwunde in das rostrale Mittelhirn eingedrungen zu sein. Es ist deshalb wichtig zu betonen dass die anterograde Amnesie mit Impotenz verbunden war, und dass der Patient eine ganz ungewöhnliche Toleranz für Schmerz aufwies.