SHORT REPORT

Retrograde temporal order amnesia resulting from damage to the fornix

Fumihiko Yasuno, Masayuki Hirata, Hiroshi Takimoto, Masaaki Taniguchi, Yoshitsugu Nakagawa, Yoshitaka Ikejiri, Takashi Nishikawa, Kazuhiro Shinozaki, Hirotaka Tanabe, Yoshiro Sugita, Masatoshi Takeda

Abstract
Some amnesic patients show an impairment of temporal order memory that cannot be accounted for by content memory deficits. The performance of an amnesic patient on memory tasks assessing the patient's content and temporal memories for remotely acquired material is described, after a lesion including the bilateral anterior fornix and adjacent anterior thalamus. The patient displayed a deficit in the temporal order tasks for remotely acquired information. Neither frontal cognitive deficits nor recognition deficits can account for this patient's poor temporal memory. This retrograde temporal order memory impairment without content memory deficits were not seen in previously reported thalamic amnesic patients. Accordingly, the patient's poor retrograde temporal memory could hardly be explained by only a thalamic lesion. It is concluded that the patient's impairment of temporal order memory for the retrograde material is probably due to the direct disconnection between the frontal lobe and the hippocampus by disruption of the fornix.

Keywords: fornix; thalamus; amnesia; temporal order

Method
CASE REPORT
A 51 year old right handed high school educated woman was admitted to our hospital in November 1995, after an episode of disorientation, amnesia, headache, nausea, and vomiting. Brain CT and MRI disclosed a cavernous haemangioma situated in the anterior part of the third ventricle with obstructive hydrocephalus. A fenestration of transparent septum and placement of a ventriculoperitoneal shunt for the hydrocephalus were performed. The tumour was not resected, to prevent hemorrhage. There were no operative complications and the patient's recovery in the immediate postoperative period was uneventful.

Several weeks after the operation, she was unable to recall any of the events surrounding her illness, and showed difficulty in recent memory retrieval. Brain MRI performed 2 months after the surgery showed an area of cavernous haemangiomia in the anterior part of the third ventricle (figure A). The lesion involved the bilateral anterior fornix and the anterior parts of medial thalamus (figure B, C).

Single photon emission computed tomography (SPECT) carried out after the surgery showed an abnormal distribution of the tracer in the lesion, whereas in other areas its uptake was normal.

Neuropsychological evaluation
An extensive neuropsychological evaluation was performed between 2 and 5 months after the operation. The patient's scores are given in the table. There were no remarkable abnormalities except for anterograde memory deficits. The patient's retrograde memory was assessed by a structured interview covering past personal events. In addition, the famous faces and events test was administered, on which she was shown pictures and asked the names of the pictured subjects or events. In both of these tests, there was no evidence of significant retrograde amnesia.

Retrograde temporal order memory
When we asked the patient about the temporal order of the past events, she showed difficulties in both the autobiographical and the famous persons or events tests. For example, she could
tell us the details of travels with her family in
the previous year and 5 years earlier, but when
we asked her which event had occurred first or
after the other, she made a mistake. She knew
very well that a major earthquake had occurred
in Japan in the previous year and that a major
international airport was opened nearby 2
years earlier, both of which were very familiar
events in her living area, but she could not
decide which event had occurred first or
second. In the temporal order tasks, she stated
that she felt confused when remembering the
order of the events, even though the events
were familiar to her.

Experimental procedures for testing retrograde
temporal order memory
Retrograde temporal order memory was evalu-
ated using public events arrangement tasks
from Bowers et al for this task, items were
taken from the pictures used in the famous
temporal faces or events test for the evaluation of the
patient’s past event memory. A total of 40 items
was used, consisting of 10 from each decade
from the 1960s to the 1990s. Each item was
presented on a card. For each trial, the subject
was presented with a set of four cards, one for
each decade, arranged in a random order. The
subject was then asked to order the four events
according to their time of occurrence, starting
with the most remote event and completing the
set with the most recent one. Ten trials were
administered in this way. The accuracy of
placement per decade and global arrangement
score were calculated. The accuracy of place-
ment per decade was based on the number of
items per decade placed in the correct position
within a set. The global arrangement score was
a vector score based on the distance between
the correct response and the subject’s response.
For each item within a set, the absolute differ-
ence was taken between the position given to
the item by the subject and its correct items
within a set. For example, a response (1960s,
The lesion in the present patient included not only the fornix but also parts of the dorso-medial and anterior thalamic nuclei, so it is possible that the additional damage to the dorso-medial or anterior thalamic nuclei affected her temporal order memory. However, retrograde temporal order deficits without amnesia for content memories were not seen in the previous reports of thalamic amnesic patients. Accordingly, the present patient’s retrograde temporal order memory impairment could hardly be explained by only the thalamic lesion. We consider that this patient’s impairment of temporal order memory for the retrograde material is affected by the damage to the fornix.

The mechanism underlying temporal ordering is not known. Several suggestions have been made regarding possible mechanisms. Deutsch suggested two complementary mechanisms for making temporal judgments, one based on a summation of memory traces and one based on comparisons between traces. He does not propose specific anatomical sites for these systems, but Sagar et al. proposed that the comparator may be a frontally based system and involve mediation, whereas the summation may be more factually represented and may be based on the limbic-diencephalic system.

Damage to either system may impair temporal contextual memory, but content memory is also affected in many patients with damage to the limbic-diencephalic system. With damage to the frontally based system, the content memory is relatively preserved. This consideration is supported by the performance in content recognition and recency discrimination shown by amnesic patients.

Parkin and Hunkin showed that impairments on anterograde measures of temporal context were due to midline diencephalic lesions, but temporal judgments about retrograde memories might depend on intact fronto-limbic functioning. Their result also indicated the existence of two different complementary mechanisms for making temporal judgments in the limbic-diencephalic system and the fronto-basal system.

The present patient showed impaired temporal order judgment for the retrograde material that cannot be accounted for by impaired content memory, and this performance was the same as that of the patient who has damage to the fronto-limbic system. Although the patient’s lesion did not involve the frontal region, most fibres interconnecting the mesial frontal area (including the medial septal/diagonal band complex) with the hippocampal formation pass through the fornix-fimbria system, so that her lesion directly disconnected the frontal lobe and the hippocampus by disrupting the information conveyed in the fornix. This disruption might result in the present patient’s retrograde temporal ordering deficit.

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