

This article was downloaded by: [University of Illinois at Urbana-Champaign]

On: 25 August 2014, At: 05:38

Publisher: Routledge

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Journal of Clinical and Experimental Neuropsychology

Publication details, including instructions for authors and
subscription information:

<http://www.tandfonline.com/loi/ncen19>

Mnemonic performance profile of a bilateral diencephalic infarct patient with preserved intelligence and severe amnesic disturbances

Hans J. Markowitsch ^a, D. Yves von Cramon ^b & Uwe Schuri ^b

^a Physiological Psychology, University of Bielefeld, and
Neuropsychology, City Hospital Munich-Bogenhausen, Germany

^b Neuropsychology, City Hospital Munich-Bogenhausen, Germany

Published online: 04 Jan 2008.

To cite this article: Hans J. Markowitsch, D. Yves von Cramon & Uwe Schuri (1993) Mnestic performance profile of a bilateral diencephalic infarct patient with preserved intelligence and severe amnesic disturbances, *Journal of Clinical and Experimental Neuropsychology*, 15:5, 627-652, DOI: [10.1080/01688639308402586](http://dx.doi.org/10.1080/01688639308402586)

To link to this article: <http://dx.doi.org/10.1080/01688639308402586>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms &

Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

Mnemonic Performance Profile of a Bilateral Diencephalic Infarct Patient with Preserved Intelligence and Severe Amnesic Disturbances*

Hans J. Markowitsch¹, D. Yves von Cramon², and Uwe Schuri²

¹ Physiological Psychology, University of Bielefeld, and ² Neuropsychology, City Hospital Munich-Bogenhausen, Germany

ABSTRACT

The case of a patient with above-average intelligence and educational background, high motivation, and an approximate IQ-MQ difference of 40 points is documented. The patient has been examined repeatedly for nearly a decade. Extensive neuroradiological material of his focal bilateral brain damage in the dorsal diencephalon is available. A widespread range of cognitive tests was used to investigate his actual performance on all relevant aspects of intelligence, attention, subjective memory, immediate retention, learning, skill and problem solving abilities, concept formation, cognitive flexibility, priming, constructional ability, retrograde memory, and long-term retention. The total of more than 50 tests included German-language forms of the revised Wechsler Memory Scale and of the Rivermead Behavioural Memory Test. The patient's short-term memory and attention were, in spite of his advanced years, average or well above average. He gave a number of examples of still intact skills and implicit memory abilities, though there was no uniformity in his performance on implicit memory tests (e.g., with respect to stored vs. new implicit information). He had no awareness of his severe anterograde and retrograde amnesia, documented over a large range of verbal and figural tests. Taken together, the results from our patient confirm the principal dichotomy between declarative and nondeclarative mnemonic functions, but give evidence for some restrictions as well. They furthermore demonstrate that focal diencephalic damage may result in profound anterograde and selective retrograde amnesia, especially with respect to data-based material, and that disconnecting portions of the medial and basolateral limbic circuits has devastating consequences on memory.

There is marked disagreement with respect to the possible contributions of individual structures – nuclear and fiber systems – to the various stages of long-term information processing. The central nuclear masses of interest are the mediodorsal thalamic nucleus and the mammillary bodies; sometimes the anterior group of nuclei is mentioned as well, as it constitutes the target of the mammillothalamic

* We would like to thank Frau PD Dr. von Einsiedel (Dept. of Neuroradiology, Technical University of Munich) for her willingness to carry out the MRI scanning. Furthermore, we thank David Emmans for correcting the language of the article. The research of one of the authors was supported by grant Ma 795/9-3 of the Deutsche Forschungsgemeinschaft. Address all correspondence to: H.J. Markowitsch, Physiological Psychology, University of Bielefeld, P.O. Box 10 01 31, D-33501 Bielefeld, Germany.

Accepted for publication: August 8, 1992.

tract and is part of the Papez circuit (Markowitsch, 1988, 1991; Markowitsch & Pritzel, 1985). From reviewing relevant studies, Markowitsch (1982) concluded that there is no well-documented case with selective mediodorsal nuclear damage and amnesia. Mair, Warrington, and Weiskrantz in 1979 observed a combined damage of principally two structures in their patients, namely a corresponding bilateral damage of the region between the mediodorsal nucleus and the subependymal tissue next to the third ventricle together with a degeneration of the mammillary nuclei. The more recently published case descriptions of two Korsakoff patients (Mayes, Meudell, Mann, & Pickering, 1988) revealed, at first glance, quite similar psychometric and neuroanatomical deviations as those in the cases of Mair and co-workers. (For the similar narrow band of gliosis in the medial thalamus, Mayes et al. concluded that its locus corresponds to that of the paratenial nucleus.) A refined analysis, however, revealed some further damage, especially in one patient. Particularly, signs of cortical atrophy were detected in one patient and reduced nucleolar volumes in layers III and V of the frontal cortex in both.

In recent years several studies (e.g., Cramon, Hebel, & Schuri, 1985; Graff-Radford, Tranel, Van Hoesen, & Brandt, 1990) and reviews (Cramon, 1992; Cramon & Markowitsch, 1992; Markowitsch, 1988) have emphasized the importance of fiber systems such as the mammillothalamic tract and the internal medullary lamina.

From the first case reports on amnesic patients (e.g., Bonhoeffer, 1901; Claparede, 1911) it was known that global amnesia is not quite as global and complete as literally suggested, but nonetheless only recent evidence has provided hints for a systematic classification of dense versus usually less affected areas of information processing in so-called amnesics. The results from the present case should be of further help in analyzing the relevant facets or dimensions of memory which are affected by dorsal diencephalic damage. In particular, we were interested in finding out whether there might be a discrepancy between general or everyday memory and more artificial, specific forms of memory, whether there might be a dissimilarity between different forms of priming, whether there is a preservation of long-term memory, whether the patient is conscious of his deficits, and whether the patient's short-term memory and other kinds of cognitive behavior, which are independent of long-term mnemonic processing, are preserved.

We had the opportunity of studying over an extended period a patient with above-average intelligence, above-average educational background (a former medical professor), high motivation and with his marital partner constantly available or present. He had an approximate IQ-MQ difference of 40 points.

CASE REPORT

On February 10, 1982, A.B., a right-handed 67-year-old retired professor, had the sudden onset of "confusion" and subsequently developed a dense retrograde

and anterograde amnesia. Neurological examination, EEG and CSF shall have been unremarkable at that time. He had no previous illness except for a "TIA" in August, 1973. There were no descriptions or signs of a chronic arterial hypertension.

On his first admission to our hospital (6/1983) the patient appeared alert and in good health. The neurological examination, the EEG, blood studies, including clotting studies, were normal. Doppler sonography hinted at an aplasia/closure of the left vertebral artery. Over the left posterior cerebral artery only a weak signal could be detected. The basilar artery revealed atherosclerotic changes without hemodynamically relevant stenosis. Cardial sources of emboli could not be found in transthoracic echocardiography. A 24-hour electrocardiogram was normal.

We personally examined A.B. on an irregular basis from May, 1983 to April, 1991. Throughout this entire period there were no obvious changes in his medical status. This was also confirmed by the patient's wife and his general practitioner. In reexamining in 1988/90 various cardiological and angiological parameters (including a transesophageal echocardiography), we confirmed the above mentioned findings.

METHODS

Neurological and Neuroradiological Examinations

CT scans were performed in June, 1983 (approximately 17 months postonset, at the patient's age of 68). Eight mm slices were obtained parallel to the fronto-occipital (FO) line. On April 9, 1991 (about 9 years postonset at the patient's age of 75) A.B. had an MRI scan, performed on a Philips Gyroscan 515. Serial T1-weighted 3 mm coronal images (TE 20; TR SE 461) through both thalami were obtained perpendicular to the FO-line. In addition, 3 mm axial slices were performed using the inversion mode (TE 30; TR IR 1900; TI 400).

Figure 1 reveals symmetrically located, columnar lesions in the polar region of both thalami afflicting all thalamic levels at least on the left side. The lesion pattern can be considered typical of infarctions in the territory of the polar ("premamillary") thalamic artery/arteries. On the left side, the lesion area appears much larger than on the right. It cannot be excluded that this lesion extends beyond the thalamic boundary to the knee of the internal capsule. At the caudal level the lesion areas on both sides come close to the bank of the third ventricle. In the more cranial sections, the lesion areas are separated from the third ventricle by a normodense band of some diameter which can be allocated to normal thalamic tissue supplied by medial branches of the posterior choroidal arteries. If this is the case the anterior thalamic nuclear complex, which is completely supplied by this vessel, should be spared on both sides.

The left lateral ventricle is slightly widened. The Septum-Caudate distance measures 15 mm on the left and 11 mm on the right. The Cella-Media-Index amounts to 0.24. The maximum width of the third ventricle is 12 mm. The caudal part of the left sylvian fissure/insular cistern is obviously enlarged without any clear indication of focal lesions other than the thalamic ones. The remainder of the brain appears inconspicuous.

MRI scans (Fig. 2) document that the thalamic lesions detected 8 years earlier and those found in 1991 are in concordance. The T1-weighted images reveal low-intensity lesions of comparable size and location in both polar thalami. The larger lesion column on

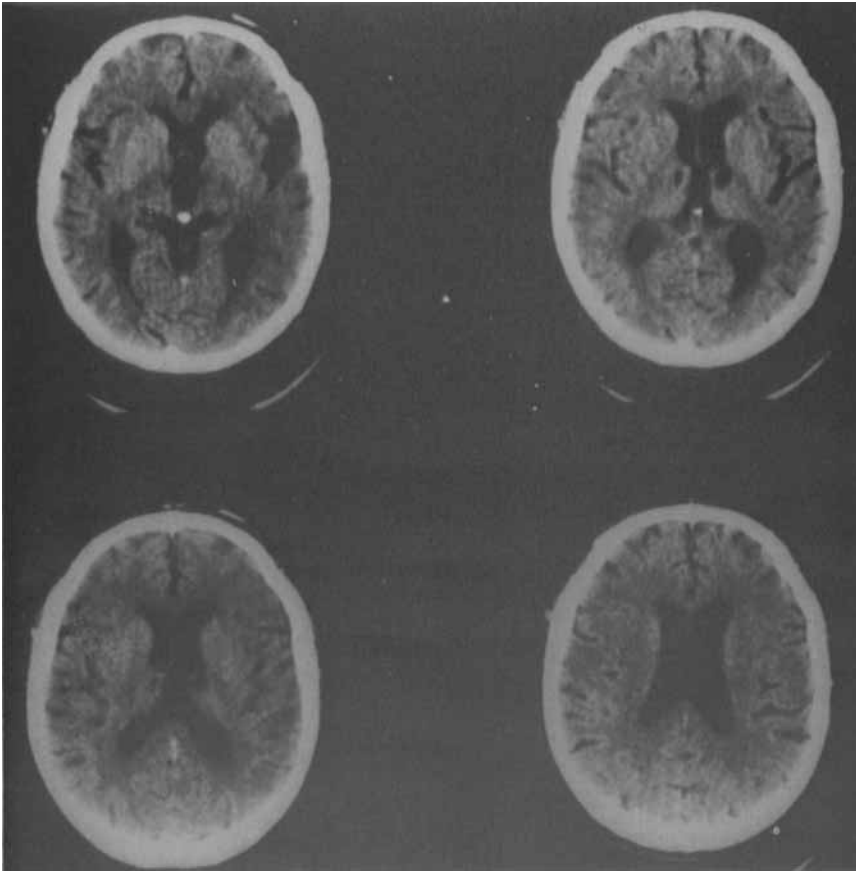


Fig. 1. Original CT scans from June, 1983 illustrate symmetrically located lesions in the polar region of both thalami. The left-sided lesion is much larger than the right-sided one. The lesion pattern appears typical of infarctions in the territory of the "polar" (pre mammillary) arteries. For details see text.

the left has a length of 10 mm and a diameter of approximately 5 mm. On the right side the considerably smaller lesion measures 5 mm and 1-2 mm respectively. The coronal slices illustrate the characteristically curved infarction areas which are clearly indicative for the supply area of the polar and paramedian group of thalamic arteries.

At the caudal thalamic level the basal portion of the medio-dorsal thalamic nucleus are most likely damaged, but also other smaller midline nuclei (e.g., parafascicular nuclei) and adjacent fiber projections (e.g., the internal medullary lamina). At the uppermost lesion level the distance from the center of the thalamic lesion columns to the sagittal plane measures about 15 mm on the left and about 10 mm on the right side. Thus, again the internal medullary lamina may be lesioned, as well as, mainly on the left side, the ventral group of the thalamic nuclei. In addition, other intrathalamic fiber projections (e.g., the mammillothalamic tract and the anterior/inferior thalamic peduncles) could be

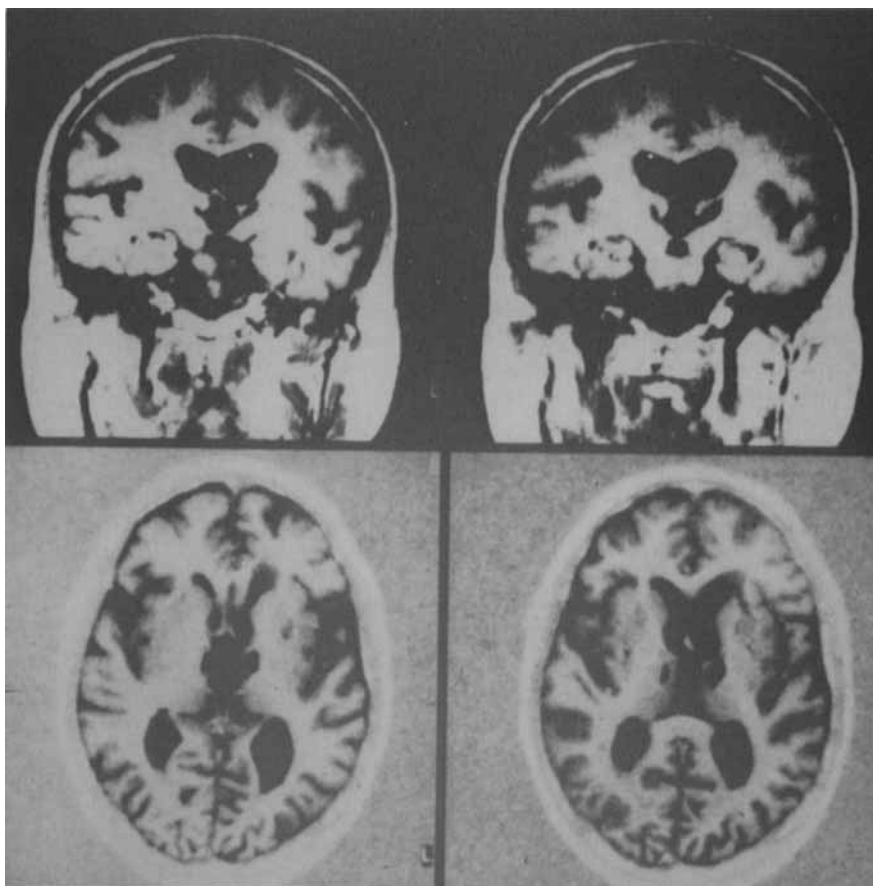


Fig. 2. MRI scans from April, 1991 documenting lesions in the polar regions of both thalami on both coronal T1-weighted (upper row) and axial inversion recovery slices (lower row). For details see text.

afflicted. The axial IR images show that the bi-thalamic lesions obviously do not cross the border of the thalamus, thus presumably sparing the adjacent internal capsule.

The central part of the left lateral ventricle is now considerably enlarged whereas other parts of the ventricle appear unchanged by comparison. The Cella-Media-Index now varies between 0.27 and 0.30. The Septum-Caudate distance and the maximum width of the third ventricle, however, have not changed. The insular cistern is slightly widened on the left side as the left slice in the upper row of Figure 2 demonstrates. The width of the sylvian fissures lies within values for age-matched controls.

We now find multiple tiny low-intensity lesions predominantly in the left hemisphere. They involve the head of the left caudate nucleus, the anterior limb of the left internal capsule as well as the putamen and the subinsular white matter on both sides. It seems plausible that the left-sided lesions constitute a substantial contribution to the enlargement of the central part of the left lateral ventricle and to the widening of the left insular

cistern. Regarding the fact that the widening of the left sylvian fissure/insular cistern was already visible on CT scans from 1983, we cannot exclude that at least some of these presumably vascular microlesions might have appeared together with the thalamic infarction(s). The case history gives no indication of additional "clinical events" since February 10, 1982.

Individuals Used for Comparison

For several of the tests (10, 20, 28, 30, 31, 36, 41-45) the patient's performance was compared with that of a 30-year-old high school teacher with a unilateral infarct of the left mediodorsal thalamic region, dating back 6 weeks from the time of testing. This patient was included as the locus of his damage was similar, but limited to one hemisphere. Furthermore, the (42) *Incomplete Pictures Test* was given to a number of control subjects for standardization and to 4 healthy control subjects for comparison with the patient's performance. These 4 control subjects were also involved in tests 41-45. Lastly, the results in the (49) *Famous Faces Test* were compared with those of 10 control subjects matched with respect to age.

Tests

We used a battery of tests which was intended to cover a wide range of aspects of learning, memory, and problem solving (Table 1). In addition, sensory and language functions and number processing were checked.

Intelligence, Attention, Subjective Memory (Tests 1-8)

The tests specified in Table 1 were used to measure intelligence and attention. A German-language adapted version of the (8) *Subjective Memory Questionnaire (SMQ)* (Bennett-Levy, & Powell, 1980) was given.

Memory Test Batteries; Immediate Retention Tests (Tests 9-20)

As overall tests a modified German-language form of the (9) *Rivermead Behavioural Memory Test (RBMT)*; Wilson, Cockburn, & Baddeley, 1984; Hempel et al., 1992) and a German-language adaptation of the (10) *revised Wechsler-Memory-Scale (WMS-R)*; Wechsler, 1987; Deisinger & Markowitsch, in press) were given. The tests for immediate retention are widely described (Lezak, 1983).

Learning (Tests 21-29)

Of the learning tests specified in Table 1, the (26, 27) *Recurring Figures and Words tests* might measure implicit memory as well, though Grafman et al. (1990) termed them to be explicit memory tests. In the (28) *learning of a mathematical rule* measure the patient was tested with five series or until he correctly formulated the underlying rule (Nichelli, Gahmanian-Behbahani, Gentilini, & Vecchi, 1988). The (29) *nonverbal selective reminding task* was given as described in Muramoto (1984).

Skill Tests (Tests 30-33)

(30, 31) *Skill acquisition*. A small table (30) *calculator* which is included in the German RBMT was given repeatedly. The subject's task was to reproduce a motor sequence which was explained verbally and demonstrated manually at the same time, namely to add or subtract four numbers in altogether nine steps (finger presses). The test was given on seven occasions distributed over four days. A (31) *puzzle* was used several times in a colored and a black form (five pieces). The (33) *mirror drawing task* was performed by using a computer-controlled monitor on which the numbers 1-20 were distributed. These numbers had to be connected in sequence by using a mouse turned 180°.

Table 1. Overview of the Tests Employed.

INTELLIGENCE

- 1) Reduced Wechsler Intelligence Test (Dahl, 1972)
- 2) Raven Standard Progressive Matrices (Raven, 1976)
- 3) Vocabulary Intelligence Test (Lehrl, 1977)

ATTENTION

- 4) Trail Making Test (Oswald & Roth, 1978)
- 5) Simple choice reaction time task (Bukasa & Wenninger, 1986a)
- 6) Fast comparison of geometric figures (Schuhfried, 1989)
- 7) Dual (divided attention) task (Bukasa & Wenninger, 1986b)

SUBJECTIVE MEMORY; MEMORY TEST BATTERIES

- 8) Subjective Memory Questionnaire (SMQ) (Bennett-Levy & Powell, 1980)
- 9) Rivermead Behavioural Memory Test: RBMT (German adaptation: Hempel et al., 1992)
- 10) Wechsler Memory Scale – Revised: WMS-R (German adaptation; Deisinger & Markowitsch, in press)

IMMEDIATE RETENTION; LEARNING

- 11) Digit span (Tewes, 1991)
- 12) Word span (Vorländer, 1987)
- 13) 10-item word list (free recall) (Schuri, 1988)
- 14) 15-item word list (Rey, trial 1) (Spree & Strauss, 1991)
- 15) 16-item word list (CVLT, German version; trial 1; Ilmberger, 1988)
- 16) Free recall of a 57-unit story (Short story) (Schuri, 1988)
- 17) Block tapping (Corsi) (Milner, 1971)
- 18) Benton test (recognition) (Benton, 1974)
- 19) Face recognition test (Warrington, 1984)
- 20) Rey-Osterrieth Complex Figure – Copying and redrawing (Osterrieth, 1944)
- 21) Word paired associates (8 pairs, 4 trials) (Schuri, 1988)
- 22) Auditory Verbal Learning Test (Rey) (Spree & Strauss, 1991)
- 23) California Verbal Learning Test (Ilmberger, 1988)
- 24) Face/name paired associates (8 pairs, 4 trials) (Schuri, 1988)
- 25) Object paired associates (Schuri, 1988)
- 26) Recurring figures test (Kimura, 1963)
- 27) Recurring word test (Stollmann, 1990; 160 nonsense words)
- 28) Learning of a mathematical rule – Fibonacci series (Wood, Ebert, & Kinsbourne, 1982)
- 29) Figural selective reminding test (Muramoto, 1984)

SKILL (LEARNING) TESTS

- 30) Skill acquisition – Table calculator (Hempel et al., 1992)
- 31) Skill acquisition – Puzzles (similar to Grafman et al., 1990)
- 32) Visually guided stylus maze (Milner, 1970)
- 33) Mirror drawing (Gatzweiler, Troppmann, & Keller, 1990)

PROBLEM SOLVING/CONCEPT FORMATION/COGNITIVE FLEXIBILITY

- 34) Tower of Hanoi (3-disk problem) (Spitz, Webster, & Borys, 1982)
- 35) Planning test (Stolze, 1991)
- 36) Concept learning – Match-to-sample version (Irie & Markowitsch, 1987)
- 37) Concept learning – Abstract concepts (Cronin-Golomb, 1986)
- 38) Wisconsin Card Sorting Test (WCST; Nelson, 1976)
- 39) Weigl's Test (De Renzi, Faglioni, Savoirdo, & Vignolo, 1966)
- 40) Transcoding – Numbers to letters (Tegnér & Nybäck, 1989)
- 41) Simple calculation (Grafman, Passafiume, Faglioni, & Boller, 1982)

IMPLICIT MEMORY/PRIMING

- 42) Gollin's Incomplete Pictures Test (Henke, Landis, & Markowitsch, in press)
- 43) Mirror image reading (Nichelli et al., 1988)
- 44) Priming – Word stem completion (Partridge et al., 1990)
- 45) Priming – Sentence completion (Schacter, 1985a, 1985b)
- 46) Priming – Phrase completion (Schacter, 1985a, 1985b)

RETROGRADE MEMORY AND LONG-TERM RETENTION

- 47) Remote memory testing – Autobiography (Schmidtke, 1990)
- 48) Remote memory testing – Famous names (Schmidtke, 1991)
- 49) Remote memory testing – Famous faces (Schuri, 1988)
- 50) Free recall of a 57-unit story after 48-hr delay (Schuri, 1988)
- 51) Recognition of 10 faces after 48-hr delay (Schuri, 1988)

Problem Solving; Concept Formation; Cognitive Flexibility (Tests 34-40)

Of these tests the (35) *Planning test* (Stolze, 1991) required the solution of three tasks of equal difficulty without a time limit. Each task comprised five different items to be scheduled on an agenda implying that all items had to be done within 6 hours (times required for a certain affair were presented on five cards). The test score was defined by the number of correctly scheduled items (maximum score $3 \times 5 = 15$ for the three tasks). (36, 37) *Concept Learning*. Two concept learning tasks were applied, one as a (36) *match-from sample task* similar to that used previously in monkeys and human beings (Irle & Markowitsch, 1987; 10 concepts), and one modified from the (37) *abstract concepts* used by Cronin-Golomb (1986) (17 concepts). The (40) *Tegnér and Nybäck (1989) test* required the subject to write in words the numbers 39, 42, 43, 274, 395, and 542.

Tests of Implicit Memory and Priming (Tests 42-46)

The (42) *Incomplete Pictures Test* was used in a version with 20 items (individual concrete objects) which were presented in 10 versions from nearly nonidentifiable [1] to complete [10] (Gollin, 1960). We (Henke, Landis, & Markowitsch, in press) had given our 10-step version to 63-80 subjects (the n depending on the picture). Based on the data of the test, subjects' cumulated percentage-ranks were calculated over the 10 steps. In this way we obtained absolute step values. The data of the 20 pictures were thus comparable and had interval scale level. The cumulated percent ranks were used as data for the analysis (cf. e.g., the results in Fig. 3).

For the (43) *mirror image reading of selected words* we followed in part the methods described in Nichelli et al. (1988) and for the (44) *word priming* (word completion) task we used a similar design as Partridge, Knight, and Feehan (1990). The (45) *sentence completion* consisted of idioms which were embedded in sentences (examples: "They sweat *blood* and *water*.", "They sank with *man* and *mouse*.") and of similarly structured sentences with two nouns which, however, were not related in an idiomatic way (example: "They cook *beef* and *vegetables*.") First, a list of all first words of the two-noun combinations was given and the patient had to add any word which came to mind (baseline). Then he was shown sentences which – for the sentences containing idioms – gave the first, but not the second word. The subject had to write the second noun in the empty place. Furthermore, the non-idiom sentences were read aloud and repeated five times. Thereafter, the same list of first words was given and the patient was asked to complete it under priming conditions. After 24 hr this list was administered a third time. The reading of the non-idiom sentences was repeated in the third session before asking the patient to complete the word pairs by adding the second word.

(46) *Phrases completion*. The third verbal priming test measured the ability to recall linguistic idioms (examples: "hot iron", "long face") (cf. Schacter, 1985a, 1985b). Here, the first word of the phrase was given and a second word had to be added by the patient. Then, sentences with the common phrases and sentences with unusual combinations (examples: "dark iron", "seventh face") were presented. After that the patient again had to complete the same list received before.

Retrograde Memory and Long Term Retention (Tests 47-51)

In order to further evaluate old memories he was given a (47) *questionnaire* which included detailed items for a number of occasions to which he had to provide answers from the period of his childhood and for the period of his last 5 years (K. Schmidtke, in preparation). Also developed by Schmidtke was a multiple-choice version of a (48) *famous persons' test* in which altogether 40 famous persons from the time period between 1960 and the present had to be identified out of four choices per person. For the (49) *famous faces test* we used 120 photographs of famous individuals covering the 55-year period from 1936 to 1990. The other tests are given in Table 1.

RESULTS

Olfaction, Vision, and Audition

Significant impairments in discriminating various olfactory and trigeminal substances were observed. The patient could not distinguish between pleasant and unpleasant odors (loss of olfactory hedonia). Visual abilities, including visual-spatial abilities, were normal. The same was true for auditory functions.

Language and Language-related Functions; Number Processing

There was no aphasia according to the Aachener Aphasia Test (Huber, Poeck, Weniger, & Willmes, 1982). The linguistic abilities, however, were supposedly below the (high) premorbid level. In spontaneous speech, short (elliptic) utterances prevailed. In responding to passive sentences, the patient often missed the "agent". He did better in judging comparative constructions. Formal testing could not reveal any dyslexic or dysgraphic errors. Aside from his limiting memory deficit difficulties in drawing inferences may be the reason for his very poor comprehension of story paragraphs.

Number processing was intact, errors in complex arithmetic tasks were due to his inability to store provisional results. In principle, operational procedures were available.

Intelligence (Tests 1-3); Attention (Tests 4-7)

The patient received the following *T* values in the German short version of the WAIS, 57 (information), 63 (similarities), 58 (picture completion), 52 (block design), and an IQ of 118 in the short vocabulary-intelligence test. In the Raven Progressive Matrices Test his value was 122.

In the attention tests there was no indication for a reduced speed of information processing. In the divided attention test he concentrated on the reaction to peripheral visual stimuli (PR 98), while his result in the tracking task was below average. Bearing in mind his age of 74 years, his overall performance appeared to be average or even above average.

Subjective Memory (Test 8); Memory Test Batteries (Tests 9 and 10)

In the SMQ the patient throughout judged his memory as "good", the only exceptions being memories for movie titles and dreams ("bad") and for birthdays and jokes ("intermediate"). The frequencies in which these acknowledged problems might occur, were rated as "very rare". The patient stated, however, that he had always had difficulties in this area.

(9) *Rivermead Behavioural Memory Test*. In the RBMT, the patient behaved particularly poorly, gaining only 24 out of 150 possible points. His general orientation was already quite reduced, that is, he could not give the proper year, month, or day, nor the locality, his age, nor the name of the president of Germany. He did not gain any points on most of the subtests; only in the tests on picture and face recognition, was he significantly above chance indicating some kind of priming or feeling-of-knowing phenomenon.

In the (10) *WMS-R* the patient's results were not consistent, though his overall general memory score was very low (65; control patient score was 71). His ability to attend and concentrate was, on the other hand, particularly high (131; control: 102). The values for verbal memory (45.5; control: 74), visual memory (79; control: 82), and for delayed recall (54; control: 71) were low or even very low (all scores age-corrected).

Though all aspects of longer memory demonstrated his profound inability to hold or reproduce information long-term, his short-term memory abilities were in contrast remarkably high. Test results for the mental control subtest gave the maximal value (6); digit span forward with 11 out of 12 points had an exceptionally high value for a person of his age and also digits backward with 9 of 12 possible points was an impressively high value. Similarly, testing visual memory span forward gave the maximal score (14) and testing backward gave 6 (of 12 possible points). Thus, his values in digit span forward and visual memory span forward were both beyond the 99th percentile.

In contrast to these high values, his figural memory was quite poor. He identified only 2 out of 10 figures. For the two stories he received just 4 (of 25) points for the first and 2 (of 25) points for the second story. Visual paired associate learning was similarly poor with 3 (of 18) points; in verbal paired associate learning he received 10 out of 24 possible points. In visual reproduction (copying four drawings immediately after having seen them) the patient was, compared to his performance in other subtests, much better (19 out of 41 points). In this test he could draw the principal Gestalts of the first three simpler figures, but was quite poor with the more complicated, fourth one, indicating that he reproduced the drawings from his short-term memory.

Particularly poor was his performance in delayed recall or reproduction subtests. He had no idea of the contents of the previously learned stories; he did not even know he had heard them. Giving him clues failed to refresh any memory. Visual and verbal paired associate recall resulted in 0 (of 6) and 2 (of 8) points and visual reproduction after delay provided no points. As in delayed story recall, the patient had no knowledge that he had made any drawings at all before. The results of the *WMS-R* therefore demonstrated a clear dissociation between short- and long-term memory functions with the patient performing significantly above average in short-term tests and well below average in longer term and especially in long-term memory.

The unilateral thalamus-damaged patient appeared to do much better in most of the tests. His behavior in verbal memory was still much better than that of the bi-thalamic patient, but in visual memory and general memory he had very similar scores. His ability to attend/concentrate was good, but his score was much lower than that of the old patient. In delayed recall the young patient was substantially better than the old one.

Comparing the values of the two patients, their general behavioral similarity is quite impressive. However, their comparison makes all the more obvious the

very high ability of attention and concentration of the old patient, and his very poor verbal memory and delayed recall ability.

Immediate Retention (Tests 11-20)

In the tests on immediate retention the patient's performance was similar to that of the two memory test batteries. His digit span was 7, in a word span test he was able to repeat 4 short and 3 long nouns, 5 phonologically similar nouns, and 5 abstract nouns. His free recall of a short word list (13) was within normal range; in the larger word lists and the story (Tests 14-16) his performance deteriorated drastically: 3 (Test 14, trial 1), 3 (Test 15, trial 1), and 4 units in the (16) *57-unit story*. In the (17) *block tapping task*, on the other hand, he again was able to repeat 6 correct blocks. Recognition of (18) *Benton's figures* was an average score of 11 and he recognized 36 faces in the (19) *face recognition test*, which is only slightly subaverage, considering his age. (Diesfeldt, 1990, reported for normal subjects under 80 years of age a mean of 41.5 ± 22.5 SD.)

The patient was quite good at copying the (20) *Rey-Osterrieth figure* (with 34 points at the 80th percentile), but totally unable to draw it without seeing the pattern. For comparison, the young diencephalic damaged patient gained 20 1/2 points from drawing the figure from memory and was therefore approaching the level of the 40th percentile.

Learning (Tests 21-29)

In the (21) *8-pair PA task* he was clearly deficient, manifesting a performance of 0, 1, 2, and 3 correct responses in the four trials given. In the (22) *AVLT* and the (23) *CVLT* his performance was clearly subaverage as well, with – for the (22) *AVLT* – productions of 3, 3, 3, 3, and 4 correct responses, then 3 responses to list B, and finally no response to list A. So his total learning was 19, while Ivnik et al. (1990) found a mean value of 43.1 ± 29.1 as average for the age range of 70-74 years. In the (23) *CVLT* he similarly produced only 3, 4, 3, 5, and 4 correct responses, then 2 responses in the new list, none in free recall of list 1 and 1 only in cued recall of list 1. Then, in long-term free recall, cued recall, and recognition he gave 0, 0, and 2 correct responses. In the (24) *face/name PA test* with 8 pairs he gave 0, 4, 1, and 1 correct responses, and in the (25) *object PA* (8 pairs) 1, 0, 0, and 1 answers.

In the Kimura (1963) form of the (26) *recurring figures test* the patient was somewhat unsure in the first quarter of the test, but then he became quite strict and definite with his answers until – at the end – his concentration loosened. With altogether 45 out of 56 correctly identified figures and no false positive answers our patient scored well above the average of the sample of 427 healthy persons tested by Hartje and Rixecker (1978) (34.7 figures) and was still well above the average of all normals with university education, tested by Hartje and Rixecker, receiving a value which was exceeded by less than a quarter of this sample of normals.

In the (27) *Recurring words test* our patient was somewhat less successful, a

finding which parallels his results in other tests such as (11) the WMS-R. He made altogether 26 correct identifications (and 2 false positives). This value (of 24) is subaverage even considering the patient's age (the *T* value of 38 is exceeded by 87% of the norm population).

The patient and the young patient were both able from the end of the first series to predict the number and to formulate the (28) *Fibonacci rule*. This superior performance (compared to that of normal subjects or other patients; cf. Nichelli et al., 1988) was most likely due to the spare time activities of the old patient and, for the young patient, to the fact that he had been tested and trained throughout the 6 weeks prior to our examination (in another clinic).

In the (29) *figural form of the selective reminding test* the patient performed well below average. He located 7, 0, 7, 2, 8, 3, 6, 5, 5, and 2 objects correctly over the 10 trials and made altogether 22 intrusion errors.

Skill (Learning) Tests (Tests 30-33)

The (30) *skill learning by use of a calculator* was given on seven occasions distributed over four days. The first time (morning session) he had absolutely no idea how to perform on the test. He did not know what to do or why to do anything. The same was true on the second occasion. On the third occasion he just pressed "8", "+", and "1". For the fourth session we then modified the test by demonstrating to him just the first six steps (adding 4 to 8 and subtracting 3). He was able to repeat immediately this abbreviated form, indicating that his short-term memory span was normal (if not superior to normal) and that interference factors from the longer (complete) test sequence might have kept him from even starting with performance. This hypothesis appeared likely on the fifth session. When showing him the complete 9-step version again, he refused to do anything ("I cannot do this."). We therefore helped him ('step by step') and then, in the final two sessions he showed at least some knowledge what the calculator was for and – with help – was able to do some presses without, however, having remembered the exact numbers or the sequence of ++–+.

The young patient was given the calculator test twice. In the first session he was unable to follow the instructions: He just pressed '8', 'M+' and then (erroneously) the number '5'. In the second session he made 5 of the 9 steps correctly. This patient consequently had the ability to learn the principles of the task, but was less able to deal with it than are most other brain-damaged patients (Mayer, 1990). (Based on a sample of 165 brain-damaged patients [largely infarcts], Mayer, 1990, received an average value of 7 out of 9 correctly performed steps with immediate repetition.)

(31) *Skill acquisition – Puzzles*. Our patient had no problems with the puzzles. This was apparent from the beginning: He was quite convinced that he would manage to solve the puzzle and did so without major problems within less than 1 min – a time which is lower than that needed on the average for control subjects or multiple sclerosis patients (Calabrese, Haupts, Babinsky, & Markowitsch, 1993). In the second session he managed to complete the puzzle

pieces within about 20 s which corresponds to approximately the minimal time needed. Also, substituting the colored puzzle by a totally black version did not alter his high skill level. He was quite similar in performance to the young patient who was also above average in comparison to normal subjects and multiple sclerosis patients.

In the (32) *stylus maze* and (33) *mirror drawing tasks* he improved over trials considerably, though at the end of each testing he apparently lost concentration or showed symptoms of fatigue.

Problem solving; Concept Formation; Cognitive Flexibility (Tests 34-40)

The patient's responses in the (34) *Tower of Hanoi test* showed little improvement both with respect to the number of moves and the number of errors made and in the (35) *Planning test* he failed totally.

Probably due to the time necessary to apply the (36) *match-to-sample-concept task*, namely first the single stimulus pattern and then 10 pages each with two response stimuli, the patient was unable to identify any of the 10 concepts. In spite of being reminded from time to time what this test was intended for, he apparently failed to make the necessary comparison and to think of alternatives over time. He was quite fascinated in concrete details within the individual pictures and stressed their possible importance in spite of our repeated comments to ignore specific details and instead to look for commonalities.

In the (37) *abstract concept task*, the patient and the other unilaterally diencephalon-damaged patient had problems in verbally formulating the abstract relationship. Contrary to Cronin-Golomb's average values of over 80% in the commissurotomed subjects and of 70% or better in the aphasics, our patient received a value of only 59% and also the young patient could make correct identifications for only 71%.

In the (38) *Wisconsin Card Sorting Test* the patient behaved particularly poorly by making 36 errors within one tested category while his performance in the (39) *Weigl's test* was above average with 15 (out of 15) categories when memory load was reduced by allowing the patient to write down previous categories. The patient had no problems with the (40) *numbers to letters test*.

The (41) *simple calculations* did not pose any difficulty for the patient. He was eager to demonstrate his abilities and was accurate and precise in his formulations and writing.

Priming (Tests 42-46)

Overall the patient's performance in the (42) *Incomplete Pictures Test* test was quite poor (Fig. 3). It is noteworthy to mention that his initial guessing was already quite poor. At no occasion did he indicate that he had seen one of the figures previously or that he had done the test before. In spite of this failure to provide evidence for explicit memory, he improved from session to session.

In the first session the patient needed on average 8 steps (of 10) until he recognised which object was meant, on the second session he improved slightly,

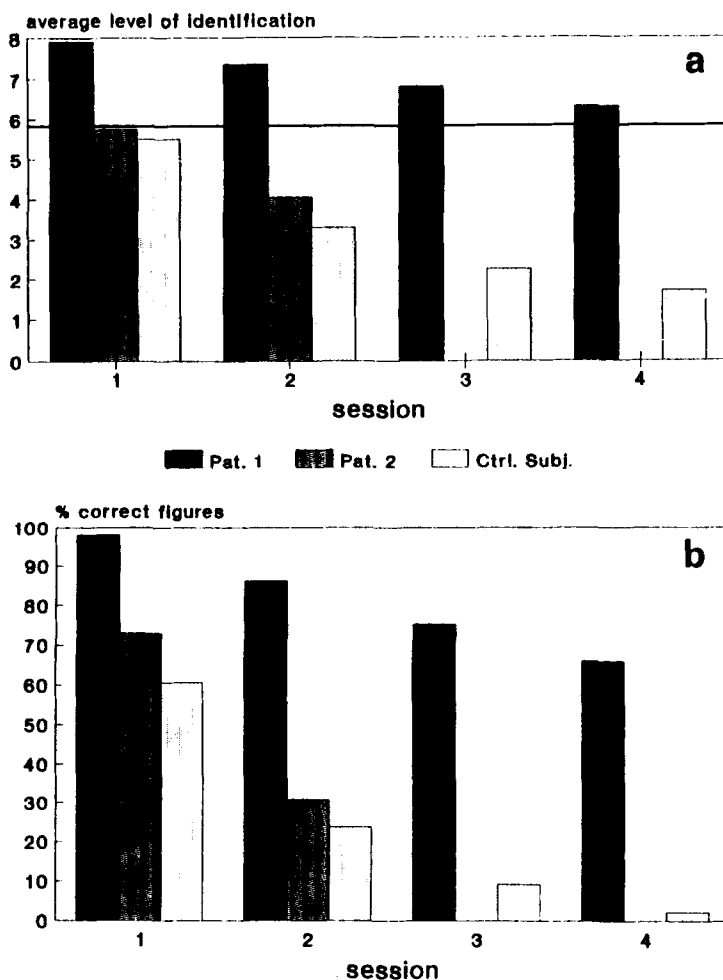


Fig. 3. Performance of the old patient (Pat. 1), the young unilaterally diencephalon damaged patient (Pat. 2) and four control subjects in Gollin's Incomplete Picture Task. Pictures were presented in 10 versions from incomplete to complete. a: Average level of identification of all 20 pictures; Patient 1 was tested in four sessions, distributed over 4 days, the young patient was tested only twice and the control subjects on four sessions. The horizontal line represents the value (5.9) at which 84 other control subjects had identified the 20 pictures. b: As the 10 steps from incomplete to complete do not reflect equal "distances" of identification, the percentage values of subjects detecting the contents of the picture at each level were taken as reference and the patients' and the control subject's performance is given in relation to these reference values. (Example for interpretation of this figure part: The first column shows that the old patient on the average detected the contents at a level where about 98% of the 84 control subjects had already identified it; the last column shows that at session 4 he still identified the contents of the 20 pictures later than did the average control subject.)

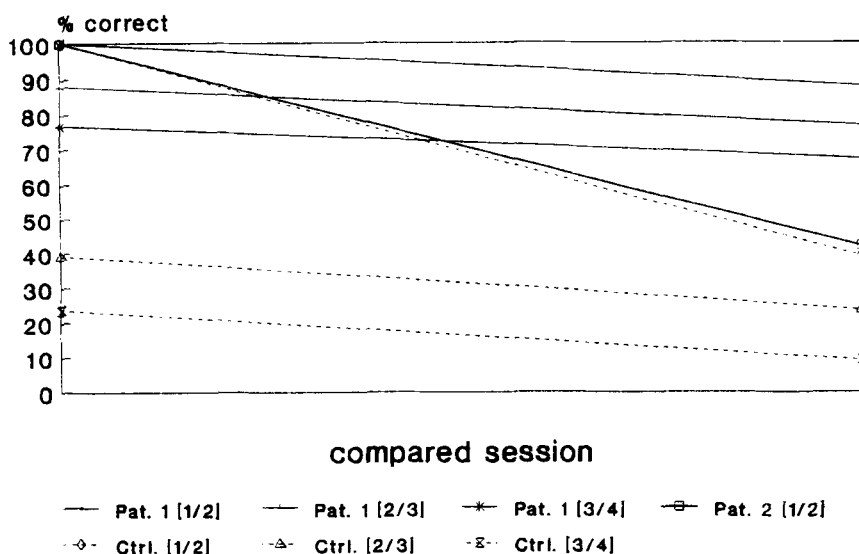


Fig. 4. Performance improvement of the old (Pat. 1) and the young (Pat. 2) patient and of the four control subjects from one session to the next (Gollin's Incomplete Figures Task). Note the almost parallel and flat curves of the old patient and the comparatively steep ones much more similar in the young patient and the control subjects from session 1 to 2.

but significantly (Wilcoxon test; $z = -1.92$, $p < 0.05$) and this improvement also continued during the final two testing sessions, though it was much less than that of the young patient or that of the control group. The same trend was seen when using percentage values (Fig. 3b).

Figure 4 shows the slow and constant slope of his implicit learning. While from session 1 to session 2 the young patient had nearly the slope of the control subject (0.25 and 0.26), the old patient had an extremely flat slope (0.05) which furthermore was extremely constant from session to session (the percentage of reduction varying for all three comparisons between 87.39 and 87.89% of the original value!).

The patient was apparently well prepared for (43) *mirror-image reading* of presented words. He needed on the average less than 4 s to give the correct response. Therefore the sheer motor-behavior dependent times such as eye and lip movements determined a large portion of the necessary time for responding. These factors in combination discouraged testing of a possible learning progress over blocks of words. Instead, we looked for evidence of improved performance (possible priming related) when the word had been presented a second time. Here, our patient showed a slight, but consistent improvement in word reading which otherwise followed closely the time periods needed per block during the first presentation. The performance of the four young control subjects closely

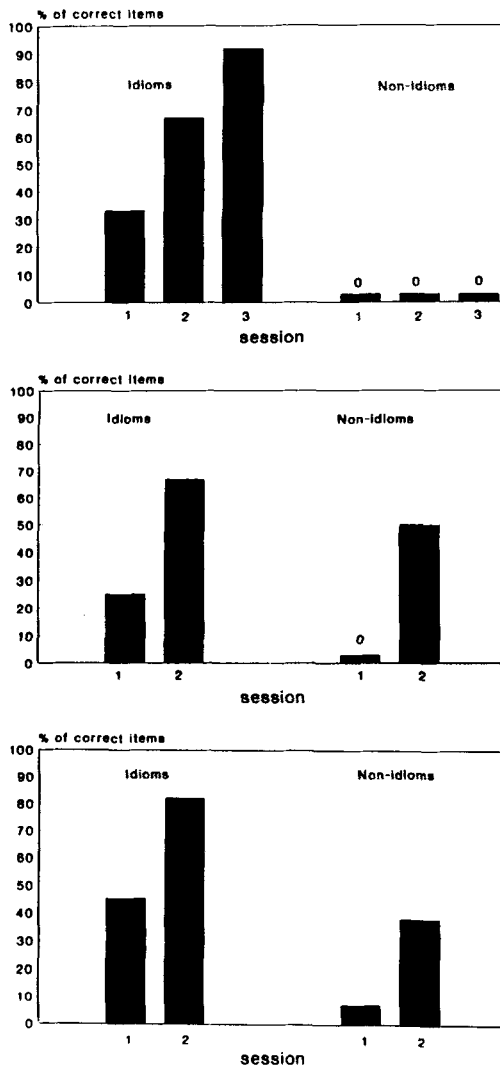


Fig. 5. Percent of correct responses given for the second word of a pair of closely associated and therefore common everyday words (idioms; example: "They sweat *blood* and *water*") or of not commonly associated words (non-idioms) (the non-idioms had been read aloud five times after the first session). *Top*: Performance of the old patient in session 1 (baseline condition; before the idiom sentences had been read aloud, but after having heard the non-idiom sentences), and in sessions 2 and 3 (after having heard and completed the idiom-sentences and having heard the non-idiom sentences a second time). *Middle*: Performance of the young patient under the same conditions, but with only one testing session (session 2) after baseline evaluation. Note that the learning progress for the non-idiom sentences is even higher than the production increase of the idioms. *Bottom*: Performance of the control subjects under the same conditions as for the young patient.

resembled that of the patient, though, of course, the controls needed only two thirds of the patient's responding times.

(44) *Word stem completion* brought ambiguous results which may in part be due to the mixed testing procedures applied and in part to the special adherence of the patient to the German language as he originally started to study German at a University before changing to the medical faculty. We therefore will not specify them here.

In the (45) *sentence completion* test the patient was given the list containing the first words of the "idiom" and the "non-idiom" sentences without having seen them; for 33% of the words ("baseline") he made correct associations (Fig. 5a). On the idiom sentences he provided correct associations for 67% of the words. This result improved to 91.7% correct when the test was repeated the next day (Fig. 5a). On the other hand, for the non-idiom sentences he failed to produce any correct association during any of the three sessions (Fig. 5a).

It is interesting to compare his results with those of the young patient (Fig. 5b) and with those of the healthy control subjects (Fig. 5c). With respect to the pairs of idioms there was a striking congruence in the results of the two patients. Both of them demonstrated a nearly equivalent baseline level (session 1) and improved to the same level after having completed the missing words in the sentences given. With respect to the pairing of non-idioms, on the other hand, their behavior was quite discrepant (Fig. 5a, b): While the old patient failed to show any learning even in session 3, the young patient gained markedly from having heard the non-idiom sentences (absolutely to a percentage higher than for the idiom sentences). It can therefore be concluded that for the young patient conscious learning was possible to a much higher degree than for the old one.

Probably due to the patient's tendency to demonstrate knowledge where it was still maintained, he produced quite unusual and in part even bizarre word phrases in the (46) *phrase completion test* so that the number of similar answers was quite low. Of the 50 words not seen before, he gave the same word for 18 of the total in session 2 as he had done in session 1 (i.e., for 36% of the words). For the idioms this value was 60%. However, probably due to the assumed tendency to give unusual answers, his production was only 5 of 8 in session 1 (directly after presentation) and 4 of 8 in session 2 (one day after presentation). Of the idioms produced correctly in the second session, only 60% were identical to those produced before.

Retrograde Memory and Long-term Retention (Tests 47-51)

In the (47) *autobiographical memory test* the patient – in spite of his age – had some knowledge of his childhood (where he gained 47 points), but he was unable to provide any memories of his recent past (2 points). In the (48) *Famous names test* he was unable to name even one out of the 40 persons. Even with respect to a famous person he had personally met about a decade ago, he failed to identify her. In the (49) *famous faces test* the patient identified for the five decades between 1936 and 1985 25%, 10%, 5%, 0%, 5% of faces in each decade respec-

tively as compared to 45%, 45%, 50%, 50%, and 60% for the age-matched controls. For the years between 1986 and 1990 he identified no face. Cues and further information helped him to identify additional portraits. The patient therefore showed his best performance in the oldest time periods measured, while the control subjects remembered most subjects from recent times.

After the 2-day delay the patient was unable to recall anything of the (50) 57-unit story. In the (51) faces recognition test he performed at chance level.

DISCUSSION

The overall impression of our case is that of a still well-behaving and educated person with obvious behavioral insecurities which are apparent both in situations of social contact and when the patient should act on his own. The patient is still reacting competitively, tries to work efficiently, and is emotionally affected in situations of obvious failure. His wife constantly trained functions which might serve to keep the patient's intellect working. For instance, she encouraged him to solve puzzles, to memorize short-term, and to perform calculations, functions which appeared well preserved (*cf. the results in the short-term tests, in tests 28, 30, 40, 41, and possibly also in test no. 33*).

A.B. nevertheless seems to have at best minimal insight into his severe disturbances. Even when commenting on some of his own statements (in the [8] SMQ) considering the way he followed all day-by-day testing implies that most of the time he does not reflect on his impairments. This judgement is confirmed in comparing his behavior with that of the second patient (who had a unilateral infarct in the same region).

Neuroanatomy

The thalamic lesions detected in 1983 and those found in 1991 are consistent. The principal lesion is precisely limited to regions within the thalamus. The larger lesion in the left hemisphere corresponds to the more severe verbal memory defects found and most likely resulted in an interruption of thalamo-cortical connections with the prefrontal and temporal cortex. The performance impairments in several of the problem solving, concept formation and cognitive flexibility tests therefore may in part be due the fronto-thalamic disconnection, particularly on the left side.

Basically Undisturbed Abilities

The patient was still clearly of superior intelligence (Tests 1-3) and usually behaved attentively (Tests 4-7, 10). Immediate retention (Tests 10-20) performance was superior as long as the item lists remained within his short-term memory span. When this was the case, he was surprisingly good, sometimes beyond the 99th percentile (10: WMS-R). Impairments in verbal supramemory span tests seem to surpass nonverbal ones (which corresponds to the larger lesion in the left hemisphere).

The patient had no problems with (28) learning a mathematical rule, with (40) transcoding numbers to letters, (41) simple calculations, with (31) solving puzzles, or in (39) Weigl's color form sorting test. This means that his cognitive flexibility was still existent on the mathematical and problem solving level(s), that is, with respect to nondeclarative memory.

From all these tests and from similar ones (e.g., 30) it became apparent that he had a high short-term memory span which, whenever exceeded, resulted in an immediate and drastic performance drop.

Learning, Concept Formation, and Cognitive Flexibility

The patient had severe learning problems both with verbal and figural material (tests 9, 10, 21-25, 29); he furthermore had massive problems in ordering his environment by identifying commonalities and differences (tests 36, 37) or by switching from one behavioral tendency to a new one (test 38). Generally, learning was substantially impaired across all modalities with at most a minor tendency for even greater problems on the verbal compared to the figural level (tests 10, 21-25, 29). This global, little differentiated, learning impairment is explainable by the bilateral, largely symmetrical, diencephalic damage.

The manifold defects early in information processing are in line with the hypothesis that diencephalic in comparison to medial temporal-lobe damage already affects the early stage of information encoding and may therefore be viewed as the most fundamental form of amnesia (Winocur, 1984).

The poor behavior in the (36, 37) concept learning tasks is attributable to possible frontal lobe signs, as the patient generally was inflexible, fixated, and as his limited memory span did not allow him to think over what had previously come to his mind. This limited memory span most likely also discouraged him from attacking similar problem analyses.

Implicit Memory Abilities

The range of implicit memory tasks used in various patient groups has considerably expanded (e.g., Grafman et al., 1990; Heindel, Salomon, & Butters, 1990; Verfaellie, Bauer, & Bowers, 1991). In parallel, the theory of implicit memory processing has been refined (e.g., Dunn & Kirsner, 1989; Horner, 1990). Hirst (1989), for example, suggested the existence of a Coherence Model which states "that amnesics encode events, but not the connections between them" (p. 33), that is, he differentiated between the encoding of content and the encoding of a 'larger context' (p. 46). The finding of Neill, Beck, Bottalico, and Molloy (1990) also seems worth mentioning that implicit, as well as explicit memory, depend more on the similarity of information processed during study and testing, than on similarity of type of process, whether data driven or conceptually driven.

Following this line of argument, our interpretation of our patient's performance in implicit memory tasks can demonstrate only general trends, but not strict, unequivocally determinable, inferences. Aside from tests 42-46, implicit memory processes may play a major role in the skill (learning) and problem solving tests (tests 30-33).

The occurrence of implicit memory processes seems evident from his performance in the (32) stylus maze and (33) mirror drawing tasks, but not in the more complex tests which very likely combine implicit and explicit memory components (e.g., [34] tower of Hanoi test). His performance in picture and face recognition in subtests of the (9) RBMT likewise may reflect priming or feeling-of-knowing phenomena. His results in these tests correspond to similar findings in diencephalic-damaged patients (Martone, Butters, Payne, Becker, & Sax, 1984; Nichelli et al., 1988).

Though the results in the priming tasks in general reveal that our patient was indeed capable of long-term implicit information processing, his particular history interfered with his performance: On the one hand the patient had the tendency to make things perfect or better than average; on the other hand his brain damage was long-term and severe. Both the very poor starting level in identifying the (42) incomplete pictures and his complete failure to acquire any (45) non-idiom words over three sessions reflect his profound amnesia. It seems obvious that he had at most a very limited ability to associate present and past data or to combine or reformulate time-spaced information. His continuous improvement in the (42) incomplete pictures test is all the more astonishing and documents once again the likelihood of the existence of different brain circuits for the processing of episodic and priming information (cf. Grafman et al., 1990; Heindel et al., 1990).

Another interpretation of his performance in verbal priming tasks seems likely as well: As is clearly shown in the (45) Priming – Sentence completion, the patient was quite able to (re-)learn or process known idioms (word-pair combinations), but failed to learn any newly introduced ones. It therefore seems possible that his ability for priming of stored information was preserved to a much higher degree than that for new information. The ineffective handling of the (34) tower of Hanoi problem and of the (35) Planning tests is not surprising considering the patient's severe retention deficit as soon as his short-term memory span is exceeded, and his inability to keep in mind individual steps of a larger (procedural) sequence.

Explicit Memory Abilities

The most profound deficits were found in some of the tests involving at least an intermediate memory (tests 9, 10, 21, 35, 47-51), though the patient himself principally denied his problems (test 8). As performance on the nondeclarative level was preserved to a much higher degree than on the declarative level, we conclude that reflection, time-ordering and monitoring of the own thoughts are the factors profoundly impaired in our patient.

The standard form of the (26) recurring figures test may be solved on the basis of implicit memory processing and could then explain the patient's good performance. Implicit memory processing may also have helped him in the (27) verbal analogue of the recurring test, though we assume that here the patient's obviously still large vocabulary resulted in interference effects. Furthermore, the

generally larger lesion in the left diencephalon may have contributed to the inferior behavior in the verbal as opposed to the figural form.

In all standard tests involving the active recall and retrieval of information after a time delay (tests 9, 10, 21, 50, 51) the patient was substantially impaired or failed to demonstrate any memory at all. The impairments were massive on verbal and nonverbal levels.

Of special interest was, of course, his remote memory (tests 47-49) and this in general revealed the frequently found pattern following Ribot's (1882) law: a good or even superior memory for remote events and a grossly defective memory for events from the last years. As cuing was of help in the (49) famous faces test, this and related evidence from other tests suggest that the medial diencephalic area, similar to the medial temporal-lobe area, is primarily involved in information acquisition for successful storage and not in information retrieval where the anterior temporal cortex might be more central (Kapur, Young, Bateman & Kennedy, 1989; Markowitsch et al., in press). A reduced possibility of interaction between temporal lobe and diencephalic structures (see e.g., Markowitsch, Emmans, Irle, Streicher, & Preilowski, 1985) provides a likely basis for explaining the selective remote memory defects in our patient, though he showed at most minor evidence for direct temporal lobe-related damage (subinsular bilateral white matter microlesions). Alternatively, but also in line with the disconnection argument, would be the hypothesis that a disruption of interaction with the dorsolateral prefrontal cortex may produce impoverished retrieval of remote memories (see the discussion in Markowitsch et al., in press).

The degree of remote memory impairment in so-called global amnesics has been a subject of some dispute in recent years (Cermak, 1984; Kapur et al., 1989; Mair et al., 1979; Markowitsch & Pritzel, 1985; Squire, 1987). In some cases severe retrograde amnesia may occur despite the failure to detect focal brain damage (e.g., Kapur et al., 1989; Salmon, Lasker, Butters, & Beatty, 1988) so that it has not been possible up to now to establish a direct relation to site and extent of damage. Squire (1987) discussed several studies on non-Korsakoff patients with diencephalic damage and found no consistent results for such lesioned patients. He assumed that remote memory impairment "should depend on lesions other than, and in addition to, those that produce anterograde amnesia" (p. 217).

One may speculate that remote memory impairments increase with the age of the patient at the time point of brain damage and may also increase with the duration of the anterograde amnesia. Assuming that old memories are stored especially in areas of the association cortex (e.g., Kapur et al., 1989) and that information is stored in a network form as proposed, for example, by Brown (1990) and Mesulam (1990), it seems logical that for the more recent past, literally spoken, the connecting, associating strings become lost more and more due to non-use and due to their wired structure being less fine, while events from the remote past still are intensely and multiply wired so that there are (depending on use or reinforcement) still numerous ways to gain access to them. As the number of new facts and episodes is severely limited and as items of the recent past

shrink, even a rebound effect may be postulated to exist for the most remote memories which consequently may be produced with increasing frequency and detail.

The neuroanatomical diversity in cases with remote memory defects has definitely grown considerably during the last few years so that this aspect of the amnesic symptomatology at present seems far from an anatomical assignment.

FINAL CONCLUSIONS

We started with the statement that memory is a complicated matter, especially when studied in brain-damaged subjects. Our analysis of the cognitive and mnestic abilities of our patient revealed that a facade or skeleton of intellectual functions may be well-preserved in spite of profound anterograde and (more selective) retrograde amnesia, including an amnesia for everyday memories. In the absence of major cortical damage amnesic patients may indeed preserve well-functioning intellectual habitus up to old age, though being unable to reflect their behavior. Our case demonstrates that at first glance a patient may still appear highly proficient as long as he can rely on an elaborated array of skill- and training- or practice-based facilities. On the other hand selective tests clearly documented the patient's helplessness in controlling, reflecting, or even comprehending the dimension of time. (When asked about the actual year, he consistently gave that of his infarct.) The ability to integrate and to separate events in time had been lost for the period from the infarct onward. One had the feeling that consciousness was reduced in the patient and that incoming information passed by as in a state of dreaming. The quite constant mood of the patient underlined the impression of somnambulism. Already van der Horst (1932) emphasized the importance of the time dimension in amnesia by stating that memory defects in Korsakoff's patients are mainly found when "temporalization" is important. He concluded that the immediate grasping of time (as a dimension) and the functioning of the dimension of time as a principle of ordering are disturbed.

REFERENCES

- Bennett-Levy, J.M., & Powell, G.E. (1980). The subjective memory questionnaire (SMQ). An investigation into the self-reporting of 'real-life' memory skills. *British Journal of Social and Clinical Psychology*, *19*, 177-188.
- Benton, A.L. (1974). *The Revised Visual Retention Test* (4th ed.). New York: Psychological Corporation.
- Bonhoeffer, K. (1901). *Die akuten Geisteskrankheiten der Gewohnheitstrinker*. Fischer: Jena.
- Brown, N.R. (1990). Organization of public events in long-term memory. *Journal of Experimental Psychology: General*, *119*, 297-314.
- Bukasa, B., & Wenninger, U. (1986a). *DR2 Test zur Erfassung des Entscheidungs- und Reaktionsverhaltens (Manual)*. Wien: Kuratorium für Verkehrssicherheit.

- Bukasa, B., & Wenninger, U. (1986b). *PVT – Test zur Erfassung peripherer Wahrnehmungsleistungen bei gleichzeitiger Trackingaufgabe (Manual)*. Wien: Kuratorium für Verkehrssicherheit.
- Calabrese, P., Haupts, M., Babinsky, R., & Markowitsch, H.J. (1993). Das Alltagsgedächtnis von multiple Sklerose Patienten. *Zeitschrift für Neuropsychologie*, 4, 4-16.
- Cermak, L.S. (1984). The episodic-semantic distinction in amnesia. In L.R. Squire & N. Butters (Eds.), *Neuropsychology of memory* (pp. 55-62). New York: Guilford Press.
- Claparède, E. (1911). Recognition et moitié. *Archives de Psychologie*, 11, 79-90.
- Cramon, D.Y. von (1992). Focal cerebral lesions damaging (subcortical) fiber projections related to memory and learning functions in man. In G. Vallar (Ed.), *Neuropsychological disorders associated with subcortical lesions* (pp. 132-141). Oxford: Oxford University Press.
- Cramon, D.Y. von, Hebel, N., & Schuri, U. (1985). A contribution to the anatomical basis of thalamic amnesia. *Brain*, 108, 993-1008.
- Cramon, D.Y. von, & Markowitsch, H.J. (1992). The problem of "localising" memory in focal cerebro-vascular lesions. In L.R. Squire & N. Butters (Eds.), *Neuropsychology of memory* (2nd ed.). (pp. 95-105). New York: Guilford Press.
- Cronin-Golomb, A. (1986). Comprehension of abstract concepts in right and left hemispheres of complete commissurotomy subjects. *Neuropsychologia*, 24, 881-887.
- Dahl, G. (1972). *WIP-Reduzierter Wechsler-Intelligenztest*. Meisenheim am Glan: Hain.
- Deisinger, K., & Markowitsch, H.J. (in press). *Der revidierte Wechsler-Gedächtnistest*. Bern: Huber.
- De Renzi, E., Faglioni, P., Savoirdo, M., & Vignolo, L.A. (1966). The influence of aphasia and of the hemisphere side of the cerebral lesion on abstract thinking. *Cortex*, 2, 399-420.
- Diesfeldt, H.F.A. (1990). Recognition memory for words and faces in primary degenerative dementia of the Alzheimer Type and normal old age. *Journal of Clinical and Experimental Neuropsychology*, 12, 931-945.
- Dunn, J.C., & Kirsner, K. (1989). Implicit memory: Task or process? In S. Lewandowsky, J.C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 17-31). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Gatzweiler, B., Troppmann, N., & Keller, I. (1990). *Visuomotorisches Lernen*. München: EKN-Materialien für die Rehabilitation.
- Gollin, E.S. (1960). Developmental studies of visual recognition of incomplete objects. *Perceptual and Motor Skills*, 11, 289-298.
- Graff-Radford, N.R., Tranel, D., Van Hoesen, G., & Brandt, J.P. (1990). Diencephalic amnesia. *Brain*, 113, 1-25.
- Grafman, J., Passafiume, D., Faglioni, P., & Boller, F. (1982). Calculation disturbances in adults with focal hemispheric damage. *Cortex*, 18, 37-50.
- Grafman, J., Weingartner, H., Newhouse, P.A., Thompson, K., Lalonde, F., Litvan, I., Molchan, S., & Sunderland, T. (1990). Implicit learning in patients with Alzheimer's disease. *Pharmacopsychiatry*, 23, 94-101.
- Hartje, W., & Rixecker, H. (1978). Der Recurring-Figures-Test von Kimura. Normierung einer deutschen Stichprobe. *Nervenarzt*, 49, 354-356.
- Heindel, W.C., Salomon, D.P., & Butters, N. (1990). Pictorial priming and cued recall in Alzheimer's and Huntington's disease. *Brain and Cognition*, 13, 282-295.
- Hempel, U., Deisinger, K., Markowitsch, H.J., Kessler, J., Hofmann, E., & Calabrese, C. (1992). *Alltagsgedächtnistest*. Weinheim: Beltz-Test-Gesellschaft.
- Henke, K., Landis, T., & Markowitsch, H.J. (in press). Lateralized perception of subawareness words, faces, and pictures. *Consciousness and Cognition*.
- Hirst, W. (1989). On consciousness, recall, recognition, and the architecture of memory. In S. Lewandowsky, J.C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 33-46). Hillsdale, NJ: Lawrence Erlbaum Associates.

- Horner, M.D. (1990). Psychobiological evidence for the distinction between episodic and semantic memory. *Neuropsychology Review*, 1, 281-321.
- Huber, W., Poeck, K., Weniger, D., & Willmes, K. (1982). *Der Aachener Aphasie Test*. Göttingen: Hogrefe.
- Ilmberger, J. (1988). *Münchener verbaler Gedächtnistest*. Munich: Ludwig-Maximilian-University.
- Irle, E., & Markowitsch, H.J. (1987). Conceptualization without specific training in squirrel monkeys (*Saimiri sciureus*): A test using the non-match-to-sample procedure. *Journal of Comparative Psychology*, 101, 305-311.
- Ivnik, R.J., Malec, J.F., Tangalos, E.G., Petersen, R.C., Kokmen, E., & Kurland, L.T. (1990). The Auditory-Verbal Learning Test (AVLT): Norms for ages 55 years and older. *Psychological Assessment*, 2, 298-303.
- Kapur, N., Young, A., Bateman, D., & Kennedy, P. (1989). Focal retrograde amnesia: A long-term clinical and neuropsychological follow-up. *Cortex*, 25, 387-402.
- Kimura, D. (1963). Right temporal-lobe damage. *Archives of Neurology*, 8, 264-271.
- Lehrl, S. (1977). *Mehrfach-Wortschatz-Intelligenztest MWT-B*. Erlangen: Perimed Verlag Dr. med. D. Straube.
- Lezak, M.D. (1983). *Neuropsychological assessment* (2nd ed.). New York: Oxford University Press.
- Mair, W.G.P., Warrington, E.K., & Weiskrantz, L. (1979). Memory disorders in Korsakoff's psychosis. A neuropathological and neuropsychological investigation of two cases. *Brain*, 102, 749-783.
- Markowitsch, H.J. (1982). Thalamic mediodorsal nucleus and memory: A critical evaluation of studies in animals and man. *Neurosciences and Biobehavioral Reviews*, 6, 351-380.
- Markowitsch, H.J. (1988). Diencephalic amnesia: A reorientation towards tracts? *Brain Research Reviews*, 13, 351-370.
- Markowitsch, H.J. (1991). Memory disorders after diencephalic damage. In W.C. Abraham, M.C. Corballis, & K.G. White (Eds.), *Memory mechanisms: A tribute to G.V. Goddard* (pp. 175-194). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Markowitsch, H.J., Calabrese, P., Haupts, M., Durwen, H.F., Liess, J., & Gehlen, W. (in press). Searching for the anatomical basis of retrograde amnesia. *Journal of Clinical and Experimental Neuropsychology*.
- Markowitsch, H.J., Emmans, D., Irle, E., Streicher, M., & Preilowski, B. (1985). Cortical and subcortical afferent connections of the primate's temporal pole: A study of rhesus monkeys, squirrel monkeys, and marmosets. *Journal of Comparative Neurology*, 242, 425-458.
- Markowitsch, H.J., & Pritzel, M. (1985). The neuropathology of amnesia. *Progress in Neurobiology*, 25, 189-287.
- Martone, M., Butters, N., Payne, M., Becker, J.T., & Sax, D.S. (1984). Dissociations between skill learning and verbal recognition in amnesia and dementia. *Archives of Neurology*, 41, 965-970.
- Mayer, B. (1990). *Testkritische Überprüfung und vorläufige Normierung des Rivermead Behavioural Memory Test*. Unpublished diploma thesis, University of Konstanz, Germany.
- Mayes, A.R., Meudell, P.R., Mann, D., & Pickering, A. (1988). Location of lesions in Korsakoff's syndrome: Neuropsychological and neuropathological data on two patients. *Cortex*, 24, 367-388.
- Mesulam, M.-M. (1990). Large-scale neurocognitive networks and distributed processing for attention, language, and memory. *Annals of Neurology*, 28, 597-613.
- Milner, B. (1970). Memory and the medial temporal regions of the brain. In K.H. Pribram & D.E. Broadbent (Eds.), *Biology of memory* (pp. 29-50). New York: Academic Press.

- Milner, B. (1971). Interhemispheric differences and psychological processes. *British Medical Bulletin*, 27, 273-277.
- Muramoto, O. (1984). Selective reminding in normal and demented aged people: Auditory verbal versus visual spatial task. *Cortex*, 20, 461-478.
- Neill, W.T., Beck, J.L., Bottalico, K.S., & Molloy, R.D. (1990). Effects of intentional versus incidental learning on explicit and implicit tests of memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 457-463.
- Nelson, H.E. (1976). A modified card sorting test sensitive to frontal lobe defects. *Cortex*, 12, 313-324.
- Nichelli, P., Gahmanian-Behbahani, G., Gentilini, M., & Vecchi, A. (1988). Preserved memory abilities in thalamic amnesia. *Brain*, 111, 1337-1353.
- Osterrieth, P.A. (1944). Le test de copie d'une figure complexe. *Archives de Psychologie*, 30, 206-356.
- Oswald, W.D., & Roth, E. (1978). *Der Zahlen-Verbindungs-Test (ZVT)*. Göttingen: Hogrefe.
- Partridge, F.M., Knight, R.G., & Feehan, M. (1990). Direct and indirect memory performance in patients with senile dementia. *Psychological Medicine*, 20, 111-118.
- Raven, J.C. (1976). *Standard Progressive Matrices*. Oxford: Oxford University Press.
- Ribot, T. (1882). *Diseases of memory*. New York: D. Appleton & Co.
- Salmon, D.P., Lasker, B.R., Butters, N., & Beatty, W.W. (1988). Remote memory in a patient with circumscribed amnesia. *Brain and Cognition*, 7, 201-211.
- Schacter, D.L. (1985a). Multiple forms of memory in humans and animals. In N. Weinberger, J. McGaugh, & G. Lynch (Eds.), *Memory systems of the brain: Animal and human cognitive processes* (pp. 351-379). New York: Guilford Press.
- Schacter, D.L. (1985b). Priming of old and new knowledge in amnesic patients and normal subjects. *Annals of the New York Academy of Sciences*, 444, 44-53.
- Schmidtke, K. (1990). *Autobiographischer Altgedächtnistest*. Freiburg: University of Freiburg.
- Schmidtke, K. (1991). *Altgedächtnistest – Berühmte Personen*. Freiburg: University of Freiburg.
- Schuri, U. (1988). Lernen und Gedächtnis. In D.Y. von Cramon & J. Zihl (Eds.), *Neuropsychologische Rehabilitation* (pp. 215-247). Berlin: Springer.
- Spitz, H.H., Webster, N.A., & Borys, S.V. (1982). Further studies of the tower of Hanoi problem-solving performance of retarded young adults and nonretarded children. *Developmental Psychology*, 18, 922-930.
- Spreen, O., & Strauss, E. (1991). *A compendium of neuropsychological tests*. Oxford: Oxford University Press.
- Squire, L.R. (1987). *Memory and brain*. New York: Oxford University Press.
- Stollmann, F. (1990). *Entwicklung eines sprachlichen Gedächtnistests und einer Parallelform in Analogie zum Recurring-Figures-Test von Kimura*. Unpublished doctoral thesis, University of Aachen, Germany.
- Stolze, A. (1991). *Konstruktion eines neuropsychologischen Tests zur Messung von Planungsfähigkeiten nach Frontalhirnschädigung*. Unpublished diploma thesis, University of Konstanz, Germany.
- Tegnér, R., & Nybäck, H. (1989). "To hundred and twentyfour": A study of transcoding in dementia. *Acta Neurologica Scandinavica*, 81, 177-178.
- Tewes, U. (Ed.). (1991). *Hawie-R: Hamburg-Wechsler Intelligenztest für Erwachsene – Revision 1991*. Bern: Huber.
- Van der Horst, L. (1932). Über die Psychologie des Korsakowsyndroms. *Monatsschrift für Psychiatrie und Neurologie*, 83, 69-84.
- Verfaellie M., Bauer, R.M., & Bowers, D. (1991) Autonomic and behavioral evidence of "implicit" memory in amnesia. *Brain and Cognition*, 15, 10-25.
- Vorländer, T. (1987). *Konzeption eines klinischen Kurzzeitgedächtnis-Tests für hirngeschädigte Patienten*. Trier: University of Trier, Germany (Thesis).

- Warrington, E.K. (1984). *Recognition Memory Test*. Windsor, UK: NFER-Nelson.
- Wechsler, D. (1987). *Wechsler Memory Scale-Revised*. Manual. San Antonio, CA: Psychological Corporation.
- Wilson, B., Cockburn, J., & Baddeley, A. (1984). *The Rivermead Behavioural Memory Test*. Reading: Thames Valley Test Company.
- Winocur, G. (1984). Memory localization in the brain. In L.R. Squire, & N. Butters (Eds.), *Neuropsychology of memory* (pp. 122-133). New York: Guilford Press.
- Wood, F., Ebert, V., & Kinsbourne, M. (1982). The episodic – semantic memory distinction in memory and amnesia: Clinical and experimental observations. In L.S. Cermak (Ed.), *Human memory and amnesia* (pp. 167-193). Hillsdale, NJ: Lawrence Erlbaum Associates.