

Free recall facilitation in Cerebral Aneurysm Surgery Patients

Recordação livre facilitada em pacientes pós-cirúrgicos de aneurisma cerebral¹

²Sérgio Leme da Silva, ³Tin Po & Bueno Huang⁴, Orlando F. Amodeo.

Received and accepted during the second semester of 2005

ABSTRACT

Surgery patients with posterior and anterior cerebral aneurysms and their respective control groups were tested on their memory performance with free recall of words with no semantic relationship (unrelated lists), words with semantic relationship (related lists), words with repetition but without any semantic relationship (repeated lists) and lists of words with repetition and with a semantic relationship (repeated-related lists). In repeated-related lists of performance was superior in all groups, suggesting that words with or without a repetition with a semantic clue improved performance in memory recall. In related lists, semantic mistakes occurred in the middle positions of the list, while intrusions of repetition occurred in the primacy and middle positions of the other categories. Occurrence of intrusions suggests a proactive interference in primacy positions due to a semantic repetition factor. Retroactive interference in recency positions was due exclusively to a semantic factor. These effects were not differentiated when compared between aneurysm patient groups and their control groups; on the other side, these results show that the use of repetition and semantic relationship are useful tools in the planning of rehabilitation programs for the memory of those patients.

Keywords: cerebral aneurysms, free recall, semantic, rehabilitation

RESUMO

Avaliamos o desempenho de dois diferentes grupos de pacientes pós-cirúrgicos de aneurismas cerebrais de artérias comunicantes anterior e posterior além dos seus equivalentes grupos de voluntários normais, quanto a acertos e erros de recordação na recuperação livre de palavras sem ou com relacionamento semântico ou repetidas sem e com relacionamento semântico. Listas repetidas induziram acertos inferiores às listas com relacionamento semântico, quando combinadas essas variáveis, os acertos foram superior em todos os grupos. Sugerindo que palavras repetidas ou não, com relacionamento semântico, facilitam o desempenho de recuperação de memória. Listas com relacionamento semântico produziram erros semânticos nas posições do meio, enquanto as demais, produziram erros de repetição na

¹Study carried out at the Department of Psychobiology at the Federal University of São Paulo (Unifesp). ²Doctor of Sciences by the Unifesp, Associate Professor at the Department of Basic Psychological Processes, Institute of Psychology (IP) at the University of Brasília (UnB), and Coordinator of the Neuropsychology Service of the Medical Center for the Elderly at the University Hospital of Brasília, Brasília – DF, Brazil, fone: +55-61-3072625 - cep 70910-900 – e-mail: leme@unb.br. ³ Post-graduation student in psychology at the IP at the UnB. ⁴ Associate Professor at the Department of Psychobiology at the Unifesp.

recuperação de primazia e meio, e semânticos na recuperação da recência. Sugerindo interferências pró-ativas na primazia devido à facilitação da repetição semântica na produção dessas intrusões e interferências retroativas na recência devido à facilitação exclusivamente semântica, efeitos estes que não se diferenciaram entre os grupos de aneurismas e voluntários normais. Nossos resultados sugerem a repetição junto à semântica como possíveis ferramentas em programas clínicos para reabilitação da memória em pacientes com distúrbios amnésicos.

Palavras-chaves: aneurisma cerebral, recordação livre, semântica, reabilitação.

INTRODUCTION

The distribution of the circulation of the anterior communicating artery in the human brain encompasses the basal forebrain areas, such as the anterior commissure, the septal nuclei, the Broca's diagonal band, the Meynert's basal nucleus, the corpus callosum, the fornix and the anterior cingulum, in addition to the anterior hypothalamus, and it may have some influence on the basal nuclei^{23, 14}. The posterior communicating arteries, on the other hand, supply the posterior cerebral arteries that irrigate the cortex of the occipital lobe, which includes the whole visual cortex, the inferior or territorial surface of the temporal lobe and a narrow cortical strip along the inferior edge of the lateral side of the temporal lobe⁷.

Rupture of anterior communicating artery aneurysm may result in damage to the structures of the basal forebrain area such as the septum, the nuclei of the Broca's diagonal band, the nucleus accumbens, the fornix and the cingulum, in addition to ventral and anterior hypothalamic areas, which would cause deficits in long term declarative or explicit memories as evaluated in tasks of free recall of words and immediate visual-spatial recovery^{14, 18, 23, 24}. It would also cause a marked immediate sensitivity in tests of proactive inhibition of verbal material³¹. Rupture of anterior communicating artery aneurysm can generate diffuse lesions that reach the frontal areas and thus lead the patients to a more complex amnesic condition that involves personality changes and deficits of the executive frontal functions in tests such as the Wisconsin's Card Selection¹¹⁻¹³. Surgery patients of anterior communicating artery aneurysm, on the other hand, present a preserved memory for tasks such as recognition of verbal material, priming tasks and tests of implicit memory^{8, 13}. The post-surgery time and the position of the lesion are critical to define their neuropsychological profile¹³.

Occlusion of the posterior cerebral artery entails

temporary amnesic syndromes of the retrograde type for verbal material and retrograde amnesia for personal information, along with visual deficits⁷.

The H.M. case describes an organic amnesia determined by medial temporal lesion after a bilateral surgery that removed the parahippocampal gyrus, the entorhinal cortex, the amygdala and two thirds of the anterior hippocampus. As a result, the patient could no longer retain in mind any public or personal events that took place after the surgery, which characterizes an anterograde memory. The patient's intellectual and linguistic functions, however, remained intact²¹. Studies with chronic alcoholic patients with Korsakoff's syndrome show that these patients present lesions in diencephalic structures (the medial nucleus of the thalamus and the mamillary bodies of the hypothalamus), which characterizes a global anterograde amnesia^{26, 28}.

In spite of the similarities of the amnesic condition among temporal, frontotemporal and diencephalic affections, some differences could be observed. Patients with Korsakoff's syndrome are usually anosognosic, or are not aware of their memory problem, and also confabulate, unlike the patients with temporal lesion^{26, 28}. Patients with frontoparietal lesion with etiology of anterior communicating aneurysm, however, confabulate and present personality changes, but there are no reports of anosognosia characteristics in this type of amnesic patients. The Korsakoff's patients present symptoms that are typical of frontal lesion^{26, 28}, while patients with rupture of the anterior communicating artery aneurysm might present IQ deterioration²⁹, as is the case in patients with frontal lesions, but not the ones with medial temporal lesion^{21, 28}. Amnesic patients of Alzheimer's from moderate to severe stages, on the other hand, present deficit of semantic memory²⁸.

The patient's performance in tests of free recall of words is analyzed according to the number of correct words recalled serially, showing the effect of serial position, well

documented in the literature^{4,9,17}. In the normal population, the serial position presents a “U” shape, where two standard effects can be observed: primacy, regarding a better performance in the first items of the list, and recency, regarding the items at the end of the list. These effects were initially considered to be due to two distinct memory mechanisms, where primacy was associated to long-term memory, and recency was associated to short-term memory^{4,9,17}. However, there is no consensus according to which the recency effect would only be caused by short-term memory, or that the long-term memory could also play some role in better retrieval of the last items, or even that it would not reflect any retrieval strategy of a specific system⁹. Nowadays, the discussions on the recency are based on investigations about the working memory system that enhances the temporary manipulation and maintenance of various sensorial categories that are originated in the short term memory and there integrated, organized and related to the representation forms of the mnemonic collection existing in long term memory. The working memory system comprises a control system that is supported by three other systems: a phonological loop, made up of a phonological store and an articulatory device; a modulator of visuospatial information; and an episodic buffer⁶. It has been argued that the frequency, speed and characteristic of the stimulus might influence the primacy effect, while the recency effect might be influenced by the phonology of the stimuli, so in this sense one should consider the role played by the phonological store of the working memory system⁹.

Another explanation often mentioned for the primacy and recency effects is the interference theory. The introduction of words semantically related in the middle positions of the lists alters the pattern of the serial position curve, producing a new peak of correct recalls. This alteration, called semantic facilitation effect, has already been observed in chronic non-demented alcoholic patients (but not in alcoholic patients)²⁷, in mild Alzheimer’s patients (but not in moderate patients)¹, in patients with multiple sclerosis² and in subjects under the effect of a benzodiazepine²⁵.

Intrusions are considered mistakes that the subjects make at recall, and the most accepted hypothesis to account for those mistakes is the interference theory, according to which the information within our system competes and can lead the patient to forget or make mistakes in the recollection

of past memories. A popular explanation for the phenomenon of interference is the activation of the spreading process, in which the coding of the words memorized may or not activate the semantic network in the long term memory, connected by nodes that represent semantic contents, and the probability of an item being retrieved in a test will depend on the associative strength between these nodes^{5,16}.

OBJECTIVE

This work aimed at investigating the effects of semantic facilitation and interference, respectively regarding the correct and incorrect free recall of words presented orally in different types of word lists, in order to evaluate the performance of anterior and posterior communicating artery aneurysm surgery patients and compare them to groups of normal volunteers, and the effect of the post-surgery time in free recall. The manipulation variables were the semantic relations between the middle words in the list (semantic facilitation effect), the re-presentation of words in different lists (repetition effect with semantic relationship), effects that were positioned in the middle of the list and characterized different kinds of list, along with lists of words with no effect, and the correlation of post-surgery time with effects of free recall.

MATERIAL AND METHODS

Subjects

Out of the 43 individuals who participated in the study, 10 were anterior communicating artery aneurysm surgery patients (AcoA) and 11 were posterior communicating artery aneurysm (AcoP). There were also different two control groups of 11 volunteers each with no history of brain disorder. They were matched with the experimental groups as regards age and schooling, as shown in Table 1. The 21 brain aneurysm surgery patients were selected and recruited through the patient files at the Hospital São Paulo of UNIFESP. The patients were submitted to general evaluation of their memory and to the experimental tests between 6 and 33 month after surgery. All the participants signed a Consent Form of Free Participation that had been previously approved by the Committee of Medical Ethics of Hospital São Paulo.

TABLE 1: CHARACTERISTICS OF THE SUBJECTS

	Control of AcoA M + SEM	AcoA M + SEM	F	Control of AcoP M + SEM	AcoP M + SEM	F
N	11	10		11	11	
Age	44,0 + 3,5	46,0 + 3,1	1,45 p=0,58	46,3 + 3,4 6,0 + 1,3	47,2 + 2,7	1,55 p=0,49
Years of school	4,1 + 1,2	3,9 + 1,2	1,11 p=0,87		6,7 + 0,9	2,04 p=0,27

AcoA= anterior communicating artery aneurysm surgery patients; AcoP= posterior communicating artery aneurysm surgery patients; Control of AcoA= control group comparable the AcoA of normal volunteers; Control of AcoP= control group comparable the AcoP of normal volunteers; M= means; SEM= standard error of means; descriptive level of $p > 0,05$ without significant differences between the experimental groups and their controls as regards age and years school.

METHOD

We used two sets containing 12 lists each. Each list comprised 15 words of daily use that were read out one by one, after which free recall was carried out. The first set comprised 6 lists with semantic relationship (related lists) in the positions 7-8-9, and the other 6 lists did not present any kind of association (unrelated lists). The participant was asked to perform the free recall of words, that is, he/she was asked which words he remembered from each list, in any order.

We then applied the second set of lists, comprising 6 lists containing 3 words with semantic relationship that were repeated in each of the 6 lists in the positions 7-8-9 (repeated-related lists), and 6 other lists containing words with no semantic relationship that were repeated in each list in the middle positions (repeated lists). The recall of correct answers and intrusions was performed at the end of each list. Finally, we applied the recall required in the WMS sub-tests: delayed Logical Memory, easy and difficult Associated Pairs.

After the retrieval of correct answers (the ones remembered correctly) and the mistakes (intrusions) in the first set of 12 lists of words (related and unrelated lists), we applied 6 subtests of the Wechsler's Memory Scale-Revised (WMS-R)³²: Information, Orientation, Mental Control, forwards and backwards Digit Span, immediate and delayed Logical Memory and easy and difficult Associated Pairs.

Statistical Analysis

We used variance analysis of multiple comparisons (ANOVA) followed by the Tukey's a posteriori test (statistic program SPSS, version 11.5, 2003 - <http://www.spss.com>) to analyze the data in relation to the groups and factors (type of lists, position of the words and kind of intrusions). We used the Spearman's test to analyze correlations, and adopted a level of significance of 5%.

RESULTS

The performance of AcoA surgery patients and their controls did not show any significant differences in the WMS subtests Information, Orientation, Mental Control, forwards and backwards Digit Span. However, in the subtests of delayed Logical Memory ($F=8.4$; $p < 0.05$) and difficult and easy Associated Pairs ($F=3.03$ e 1.81 ; $p < 0.05$), the group of AcoA surgery patients presented significantly lower scores than their controls.

According to the clinical analysis of Hodges¹⁹ for the cognitive performance in tests of retrieval of complex verbal information, such as WMS Logical Memory and Associated Pairs, where the healthy patient should be able to recall around 25% of the elements of the story or of the association of pairs with immediate recall (LM1 and AP1), and also retain 60% of these elements in later recall (LM2 and AP2), we were able to identify the following: 4 AcoA surgery patients and 1 AcoP surgery patient presented deficit in immediate Logical Memory; 7 AcoA and 1 AcoP presented deficit in delayed Logical Memory; 4 AcoA presented deficit in Associated Pairs 1; and 8 AcoA and 3 AcoP presented deficit in Associated Pairs 2 (see table 2).

TABLE 2: CLINICAL HISTORY OF ANEURYSM SURGERY PATIENTS AND THEIR PERFORMANCES IN THE SUB-TESTS LM 1; LM 2; AP 1; AND AP 2 OF THE WECHSLER MEMORY SCALE (WMS).

Age	Artery	Rupture of artery	PST	Elements recalled in LM 1 and LM2	Elements recalled in AP1 and AP 2
49	Left AcoA	Yes	17	25% - *16%	31% - *13%
53	Right AcoA	Yes	18	*12% - *00%	*24% - *27%
56	Left AcoA	No	26	*22% - *32%	31% - *55%
51	Left AcoA	Yes	33	*14% - *16%	*13% - *27%
31	Right AcoA + right carotid	Yes	7	32% - *56%	31% - *41%
62	Left AcoA	Yes	31	*06% - *16%	*17% - *00%
34	Right AcoA	Yes	14	32% - 88%	41% - *55%
41	Right AcoA	Yes	22	48% - 120%	38% - 69%
42	Right AcoA	No	22	25% - 64%	*24% - *27%
41	Right AcoA	Yes	23	32% - *56%	34% - 69%

TABLE 2: CLINICAL HISTORY OF ANEURYSM SURGERY PATIENTS AND THEIR PERFORMANCES IN THE SUB-TESTS LM 1; LM 2; AP 1; AND AP 2 OF THE WECHSLER MEMORY SCALE (WMS).(CONT.)

Age	Artery	Rupture of artery	PST	Elements recalled in LM 1 and LM2	Elements recalled in AP1 and AP 2
44	Right AcoP	No	23	48% - 168%	41% - 69%
66	Right AcoP	Yes	13	36% - 96%	55% - 69%
52	Right AcoP	Yes	6	46% - 144%	52% - 97%
47	Right AcoP + Right Carotid	No	22	46% - 128%	48% - 69%
31	Right AcoP	Yes	7	38% - 152%	41% - *41%
52	Right AcoP	Yes	7	40% - 112%	38% - *55%
44	Right Carotid 3 months later Left anterior choroidal	Yes	23	*22% - *48%	59% - *55%
53	Right Carotid	Yes	11	50% - 104%	41% - 69%
43	Right Carotid + right pericallosal	Yes	10	46% - 112%	52% - 97%
39	Right Carotid	Yes	6	38% - 144%	41% - 83%
44	Right Carotid + midbrain	Yes	17	32% - 48%	62% - 83%

AcoA= anterior communicating artery aneurysm surgery patients; AcoP= posterior communicating artery aneurysm surgery patients; PST: time in months between surgery and performance of tests; LM1: immediate logical memory; LM2: delayed logical memory; AP1: immediate learning of associated pairs; AP2: delayed learning of associated pairs; * deficit identified by Hodges' clinical analysis²⁶. Carotid aneurysm surgery patients participated in the AcoP group, due to the communication of this artery with AcoP.

In the unrelated, related and repeated lists, the AcoA did not differ from their control group as to the effects of primacy, recency and middle positions in the lists (fig. 1). Only when we repeated the semantically related words (repeated-related lists) did the control group present better results than the AcoA ($F = 3.12$; $p < 0.05$). AcoA surgery patients, however, benefited from the semantic facilitation effect (fig. 1), as well as AcoP patients (fig. 2). Apart from these findings, no other differences were detected between the experimental groups and their controls regarding the words recalled from different types of list ($F = 0.83$; $p > 0.05$).

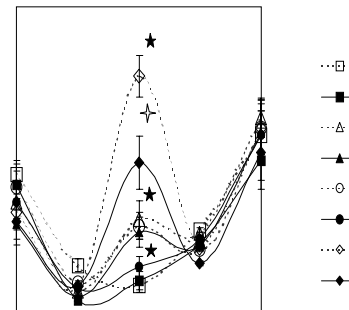


Fig. 1: Means of words recalled correctly in the experimental group AcoA (anterior communicating artery aneurysm surgery patients) and their control group (normal volunteers) in the different types of list. The $p < 0,05$ (ANOVA) showing significant differences among of words correct recall of the factor middle with unrelated list and related list; repeated-related lists and repeated lists; repeated-related lists and unrelated lists; and $p < 0,05$ showing significant differences between the groups in the repeated-related lists.

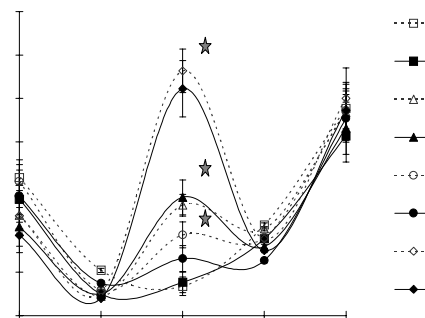


Fig. 2: Means of words recalled correctly in the experimental group AcoP (posterior communicating artery aneurysm surgery patients) and their control group (normal volunteers) in the different types of list. The $p < 0,05$ (ANOVA) showing significant differences among of words correct recall of the factor middle with unrelated list and related list; repeated-related lists and repeated lists; repeated-related lists and unrelated lists.

The AcoA group showed a significant correlation between the post-surgery time and the average number of unrelated words they recalled from the middle of the lists, that is, the shorter the post-surgery time, the lower the average number of words recalled from the middle of those lists (R Spearman = 0.69; $t = 2.70$;

$p < 0.05$). (For details of the post-surgery time of each patient, see table 2).

In order to analyze the mistakes of semantic intrusion, we considered only the associations that produced intrusions of strong semantic relationship (e.g.: sweet – honey; broom – bucket; button – coat; hammer – ax-, etc). Comparing the means of mistakes in the recall of the two variables investigated (semantic relationship and repetition), we observed that there were no significant differences among all the groups tested regarding their performance in the recall and the production of intrusion mistakes ($F = 0.98$; $p > 0.05$). We noticed that most of the intrusions that took place were associated to the repetition and the semantics, with a smaller number of intrusions of non-related words ($F = 6.79$; $p < 0.05$). However, the ANOVA detected a significant difference in the intrusions regarding the effect of serial position ($F = 7.09$; $p < 0.05$), and regarding the repeated and semantic intrusions in the unrelated and related lists ($F = 3.40$; $p < 0.05$) and in the repeated and repeated-related lists ($F = 7.0$; $p < 0.05$).

Thus, we observed that the means of total intrusions of words repeated in the list was significantly higher when they were in the beginning and the middle of the unrelated, repeated and repeated-related lists, except in the related lists, where that effect was not observed. On the other hand, the means of total intrusion mistakes of semantic words was significantly higher in the beginning of the repeated lists, but not higher than the intrusion mistakes of semantic words in the middle of the related lists.

When we compared the semantic intrusions with the repeating intrusions considering the unrelated lists, we observed that those lists accounted for a significantly higher number of intrusion mistakes than of semantic ones in the beginning of the lists of repeated words. However, when we compared the semantic intrusions in the middle of the related lists we observed that they were significantly higher than the repeated intrusions in this type of list. Considering the repeated-related lists, we observed that those lists produced a significantly higher number of repeating intrusions in the middle of the list than the semantic intrusions of the same nature. As regards the recency, however, the same repeated-related lists produced a significantly higher number of semantic intrusions than of repeating intrusions (fig. 3).

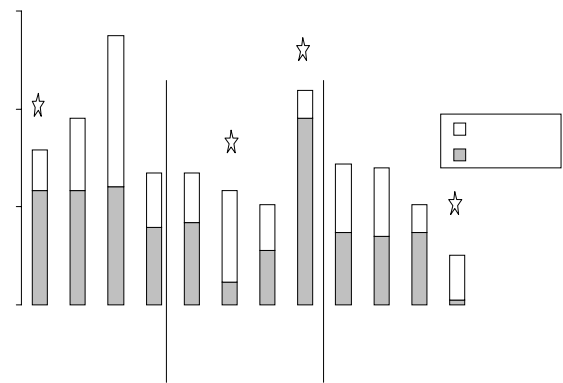


Fig. 3: Means of words recalled incorrectly due to intrusions of repeated or semantic words in the words positioned in primacy, middle of the list and recency of the different types of words lists tested: unrelated; related; repeated; and repeated-related, with $p < 0,05$ ANOVA showing significant differences between semantic and repeated intrusions.

DISCUSSION

First of all, we clearly observed the facilitation effect of recall induced by the semantically related words in aneurysm surgery patients, which corroborates the data in the literature regarding patients of other etiologies, such as chronic alcoholism, Alzheimer's and multiple sclerosis^{6,9,17}, patients who present cognitive impairment. In addition, the subjects in the experimental groups of both kinds of aneurysm, as well as the control group, also presented facilitation when the semantic and repetition factors were manipulated together. By comparing these two factors, we noticed that the task leads involving recall of words with semantic relationship the subjects to a better performance than when the repetition factor was considered, which suggests that the task where the explicit processing is required to recall a word with semantic value may be responsible for stronger facilitations than the simple repetition of the stimulus studied. This factor is discussed in the literature²², and consolidates the hypotheses according to which the semantic value of a word is much more important than the repetition, and remains relatively intact even in cases of aneurysm and mild Alzheimer's²⁰.

This corresponds to the theoretical assumptions about memory. The information processing model, for example, presupposes that the semantic and syntactic values possess different processing systems for the different types of memory systems (semantic, episodic and procedural³⁰). Damage in brain areas responsible for one of the memory systems do not necessarily imply in damage to all, since they are independent systems, except for the dependence on an intact semantic system for the formation of new episodic memories, as pointed out by the same authors³⁰. Nevertheless, clinical data^{3, 10, 15} show the importance and the strength of semantic stimuli (e.g., public figures, names, autobiographical and categories of words) in rehabilitation, independently of the patient presenting deficit of semantic memory.

Considering that there were no differences in the performance of the different groups, the evaluation of recall mistakes suggests that repeating intrusions of words in the lists take place, most of the time, in the beginning of lists that do not present merely semantic effects (unrelated, repeated and repeated-related lists). Only the semantic lists yielded semantic intrusions regarding primacy and middle position, except in the repeated-related lists. The lists with repetition of semantically associated words produced semantic intrusions in recency. Given this fact, we can raise some issues already discussed in the literature⁵ that suggest that the facilitation by semantic relationship would be due to the continuous activation of semantic traits inherent to the set of related words. The storage of words would take place by packs inside the semantic memory, and its activation would happen through a network of nodules that would keep those packs interconnected. The distance from the nodule would represent the strength of association of each pack of words. This effect was called spreading activation. The effect observed in unrelated lists with a high number of semantic intrusions regarding the words positioned in the middle of those lists (where the facilitation takes place) corroborates this hypothesis. However, when the effect is represented by repetition plus semantic association, the intrusions are characterized by being repeated words in the middle of the lists, that is, the repetition might work as a block of the spreading activation of semantic words.

When we analyze the intrusions in the light of the interference hypothesis¹⁷, regarding the serial position effect,

we can conclude that primacy could work as a proactive interference on the effects of purely semantic facilitation, stopping it from spreading to other lists, generating a higher production of recall mistakes represented by repeated words in the primacy of the unrelated, repeated and repeated-related lists, an interference that is unlikely to happen in repeated-related lists, as observed, due to its significant facilitation effect.

Recency could work as a retroactive interference on the facilitation effect of the repeated or related lists, but be incapable of blocking the production of semantic intrusions in the recency of repeated-related lists.

Finally, the combination of two factors, semantic and repetition, presented a significantly higher performance in relation to the other combinations of these variables, suggesting that the repeated word and that with semantic value might help the subjects' memory, independently of their neuropsychological deficiency.

We can conclude that both the semantic relationship and the semantic repetition of words have the same importance in the processes of storage and recall at the level of serial processing. We can assume a "co-existence" between these variables and its importance in the rehabilitation of aneurysm patients, since anterior communicating artery aneurysm surgery patients tested in this study, in agreement with the data in the literature^{11, 14, 18, 29}, presented difficulties to store verbal materials in the episodic memory, as evaluated by the WMS subtests delayed Logical Memory, and learning of easy and difficult Associated Pairs. These results show that the use of repetition and semantic relationship are useful tools in the planning of rehabilitation programs for the memory of those patients.

ACKNOWLEDGEMENTS

We thank Dr. Carlos Tomaz for his comments on an earlier version of this manuscript. This work was supported by Capes-PICD-UnB and AFIP.

REFERENCES

1. Abrisqueta-Gomez J. Avaliação neuropsicológica nas fases inicial e moderada da demência do tipo Alzheimer. [doctoral thesis]. São Paulo (SP) Brazil: Escola Paulista de Medicina, Universidade Federal de São Paulo; 1999.

2. Andrade V M, Oliveira M G M, Miranda M C, Oliveira A S B, Oliveira E M L & Bueno, O F A. Semantic relations and repetition of items enhance the free recall of words by multiple sclerosis patients. *J Clin Exp Neuropsychology* 2003 25; 8: 1070-8.
3. Ávila R, Bottino C M C, Carvalho I A M, Santos C B, Seral C & Miotto, E C. Neuropsychological rehabilitation of memory deficits and activities of daily living in patients with Alzheimer's disease: a pilot study. *Braz J Med Bio Res* 2004; 37: 1721-29.
4. Atkinson R C & Shiffrin R M The control of short-term memory. *Scientific Am* 1971 225; 2: 82-90.
5. Baddeley A D. *Human memory: theory and practice*. Revised ed. Boston (US): Allyn & Bacon Ed.; 1998.
6. Baddeley A D. The episodic buffer: a new component of working memory? *Trends Cogn Sci* 2000; 4: 417-23.
7. Benson D F, Marsden C D & Meadows J C. The amnesic syndrome of posterior cerebral artery occlusion. *Acta Neurol Scand*, 1974; 50: 133-45.
8. Bondi M W, Kaszniak A W, Rapcsak S Z & Butters, M A. Implicit and explicit memory following anterior communicating artery aneurysm rupture. *Brain & Cogn* 1993 22; 2: 213-29.
9. Capitani E, Sala S D, Logie R H & Spinnler H. Recency, primacy and memory: Reappraising and standardising the serial position curve. *Cortex* 1992; 28: 315-42.
10. Da Silva S L. Avaliação da memória em pacientes pós-cirúrgicos de aneurisma cerebral. [doctoral thesis] São Paulo (SP) Brazil: Escola Paulista de Medicina, Universidade Federal de São Paulo; 1999.
11. De Luca J. Predicting neurobehavioral patterns following anterior communicating artery aneurysms. *Cortex* 1993; 29: 639-47.
12. De Luca, J & Diamond, B J. Aneurysm of the anterior communicating artery; A review of neuroanatomical and neuropsychological sequelae. *J Clin Exp Neuropsychology* 1995 17; 1: 100-21.
13. D'esposito M, Alexander M P, Fischer R & Mcglinchey B R et al. Recovery of memory and executive function following anterior communicating artery aneurysm rupture. *J Intern Neuropsych Soc* 1996 2; 6: 565-70.
14. Diamond B J & De Luca J. Rey-Osterrieth complex figure test performance following anterior communicating artery aneurysm. *Arch Clin Neuropsychology* 1996 11; 1: 21-8.
15. Graham K S, Simons J S, Pratt K H, Patterson K & Hodges J R. Insights from semantic dementia on the relationship between episodic and semantic memory. *Neuropsychologia* 2000; 38: 313-24.
16. Greene, R L. *Human Memory: paradigms and paradoxes*. Hillsdale (NJ): Lawrence Erlbaum Associates Publishers; 1991.
17. Greene A J, Prepscius C & Levy W B. Primacy versus recency in quantitative model: Activity is the critical distinction. *Learn & Mem* 2000 7; 1: 48-57.
18. Hanley J R, Davies A D M, Downes J J & Mayes A R. Impaired recall of verbal material following rupture and repair of anterior communicating artery aneurysm. *Cognit Neuropsychol* 1994 11; 5: 543-78.
19. Hodges J R. *Testing cognitive function at the bedside. In Cognitive assessment for clinicians*. Oxford: Oxford University Press 1994, p. 108-54.
20. Milberg W & McGlinchey R. Taking the thumbs off the multidimensional scales in the debate on semantic memory and Alzheimer's disease: A comment on Storms et al. *Neuropsychology* 2003 17; 2: 312-14.
21. Milner B, Corkin S & Teuber H L. Further analysis of the hippocampal amnesic syndrome: 14 year follow up study of H.M. *Neuropsychologia* 1968; 6: 215-234.
22. Ober B A & Shenaut G K. New directions in the study of semantic deficits: A comment on Storms et al. *Neuropsychology* 2003 17; 2: 315-317.
23. Phillips S, Sangalang M D & Gwenth Sterns M E. Basal forebrain infarction, a clinicopathologic correlation. *Arch Neurology* 1987; 44: 1134-8.
24. Richardson J T E. Performance in free recall following rupture and repair of intracranial aneurysm. *Brain and Cogn* 1989; 9: 210-26.
25. Ruiz A M N. Efeito do flunitrazepam sobre a recordação livre de palavras em sujeitos normais. [dissertation] São Paulo (SP) Brazil. Escola Paulista de Medicina, Universidade Federal de São Paulo; 2000.
26. Squire L R. Comparisons between forms of amnesia: some deficits are unique to Korsakoff's syndrome. *J Exp Psychology: Learn Mem Cogn* 1982 8; 6: 560-71.
27. Silva L P. Recordação livre em pacientes alcoolistas. [dissertation] São Paulo (SP) Brazil. Escola Paulista de Medicina, Universidade Federal de São Paulo; 1997.

28. Squire L R. Memory and brain (NY) Oxford Univ. Press; 1987.
29. Stenhouse L M, Knight R G, Long More B E & Bishara S M. Long-term cognitive deficits in patients after surgery on aneurysms of anterior communicating artery. J Neurol Neurosurg & Psychiatric 1991 54; 10: 909-14.
30. Tulving E. Elements of episodic memory. (NY) Oxford Univ. Press; 1983.
31. Van Der Linden, M, Bruyer R, Rolland J & Schils J R. Proactive interference in patients with amnesia resulting from anterior communicating artery aneurysm. J Clin Exp Neuropsychology 1993 15; 4: 525-36.
32. Wechsler D. Wechsler Memory Scale – Revised. (NY) Psych Corp; 1987.

