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Luria's Memory Words Test-Revised A Study of Regional Cerebral Blood Flow in Traumatic Brain Injury Patients (Memory and learning processes are associated to left infero-posterior temporal lobe)

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This work introduces criteria validity of Luria´s Memory Words Test-Revised (LMW-R), a revision of the Luria/Christensen LMW (Christensen, A.L., Munksgaard, Copenhagen, 1975) for a qualitative assessment and diagnosis of memory disorders. Different memory indexes are provided related to the capacity and quality of memory processes and difficulties in learning and memorizing. Subjects included 7 severe traumatic brain injury patients (Glasgow Coma Scale <8) with severe memory disorders after discharge from hospital. All underwent a regional cerebral blood flow (rCBF) measurement by ^{133} Xe inhalation technique using 32 scintillation detectors placed in a helmet-type holder (see Obrist, et al., 1975). All patients belong to a severe memory problem rehabilitation group and were assessed through LMW-R. Regional cerebral blood flow data of all patients showed a hypoperfusion (mean of 11 to 15% lower) in the bilateral temporal infero-posterior lobe, more acute on the left side, and slight hypoperfusion in right infero-parietal. Other zones of the brain show a normal level of CBF. All patients have poor scores in memory gain, contamination index, fabulation index and true recall. These results show evidence for criterion validity of LMW-R for the assessment of patients with severe memory deficits associated to a functional disorder in the temporal lobes. *Key words*: memory, rCBF, neuropsychological assessment, temporal lobe

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Curva de Memoria de Luria Revisada Un Estudio a través del Flujo Sanguíneo Cerebral regional en Pacientes Traumatismo Craneoencefálico.

Este trabajo presenta la validez de criterio de la Curva de Luria Revisada para una evaluación cualitativa y para el diagnóstico de los trastornos de memoria. Se aporta diferentes índices de memoria relacionados con la capacidad y la calidad de los procesos de memoria y las dificultades para aprender y memorizar. Se estudian 7 sujetos con traumatismo craneoencefálico grave (Escala de Coma de Glasgow < 8) con trastornos severos de memoria después de su alta hospitalaria. A todos se les midió el flujo sanguíneo cerebral regional (Rcbf) a través de la técnica de inhalación de Xenon usando 32 detectores situados en el cráneo. Todos los pacientes pertenecían a un grupo que iba a comenzar un programa de rehabilitación de problemas de memoria y fueron evaluados con la Curva de Memoria Revisada. Los resulados del Rcbf muestran que todos los pacientes tenían una hipoperfusión media del 11% a 15% mas baja en las zonas temporales bilateral infero posterior. Otras zonas del cerebro mostraban niveles normales de flujo sanguíneo. Todos los pacientes mostraban puntuaciones bajas en ganancia mnésicas,índice de contaminación, índice de fabulación y recuerdo real, mostrando un índice funcional de memoria del 61%. Estos resultados muestran evidencia de validez de criterio de la curva de Memoria Revisada para la evolución de pacientes con trastornos severos de memoria asociados a un trastorno funcional de los lóbulos temporales. *Palabras clave*: memoria, Rcbf, evaluación neuropsicológica, lóbulo temporal.

Luria's Memory Word Test (LMWT) (Luria 1962), systematized by Christensen (1976) is a brief and easily administered pencil-and-paper and now computerized (see León-Carrión, 1994) measure that is used to explore and assess the qualitative and quantitative aspects of verbal learning and memory processes. The fundamentals of LMW-R can be found in Luria's description of the neuropsychology of memory (Luria 1980), and current concepts of memory. The process of memorizing is a non-singular cognitive activity requiring an equilibrium between new knowledge and already consolidated knowledge.

Memory is a complex concept that cannot be reduced to a single task and is not a unitary process. We know that lesions in different regions of the brain alter memory in different ways (Mayes 1988). Patients with acquired brain injury present a wide range of physical, physiological and social problems that are challenging in terms of assessment and rehabilitation. Memory is one of the most serious impairments influencing the process of recovery (León-Carrión,1997). One of the primary needs for the successful rehabilitation of memory problems is the improvement the tools used to

assess these deficits. Validated instruments for the assessment of organic memory disorders (OMD) are needed. The purpose of these instruments must be primarily to detect and cognitively explain the severity of the memory impairment that patients with brain damage present.

This paper investigates the criteria validity of LMW-R in order to demonstrate its effectiveness in a neurological context. Anastasi (1982) defined criterion validity as the relation between a test score and an independent external variable.

Method

Subjects

Seven subjects were studied between the ages of 18 and 40 with severe memory disorders owing to a traumatic brain injury. All of them had been discharged from the hospital more than 6 months prior, and both subjects and their families complained of significant deterioration of memory that seriously affected their daily activities. The patients formed part of a group that had been accepted to carry out a specific neuropsychological rehabilitation program for memory. All subjects, as well their family members who provided written approval, voluntarily accepted to participate in the study. Neither patients nor their family members received economic rewards for their participation in the study. The Bioethical Commission of the University approved the study. This research was done before initiating the rehabilitation program to which they had been assigned. Only patients who had obtained a score of less than 8 on the Glasgow Coma Scale during the acute phase of TBI and had low scores in the memory test were included in this study.

All of the subjects underwent a specific neurological, neuropsychological and medical examination. The characteristics of the subjects and the results of neuropsychological assessment of memory are shown in Tables 1 and 2. As can be observed in the results obtained on Luria's Memory Words-R, all subjects presented severe deficits in memory and learning ability, far below the expected score for the patient's age and cultural level. In functional terms it can be interpreted that the memory of these patients was at 60% of its capacity.

Table 1
Characteristics of the patients participating in the study.

VARIABLE	Mean	SD
GCS (Glasgow Coma Scale)	5.64	1.36
AGE	28.45	8.56
E-IQ (Estimated IQ)	93.41	11.26

According to the data our group of patients have a severe working memory deficit, with a high contamination of memory with fabulation and perseveration. Patients were aware that they have memory problems. Their learning curve is abnormal and information is being lost during the learning process. Strategies are not being used to memorize and only a recency effect is being shown. These deficit make it a difficult for patients to gain and consolidate information. Functionally ther memory volumen is at 61% of capacity.

Table 2
Mean and Standard Deviation obtained by the group patients for each of the LMW-R variables

VARIABLE	*Mean*	*S*
Total Recall	68.17	16.69
Total Recall Index	6.07	3.07
True Recall	61.33	16.15
True Recall Index	6.13	2.83
Additions	2.33	1.63
Fabulation Index	2.60	2.86
Perseverations	0.00	0.00
Adherency Index	0.00	0.00
Repetitions	2.17	2.64
Repetitions Index	2.85	3.32
Contamination Index	6.37	4.64
Aspiration Level	58.83	17.17
Aspiration Index	5.88	1.72
Index of Awareness	0.30	0.51
Index of learning 1	0.72	0.97
Index of learning 2	0.25	0.63
Index of learning 3	0.80	0.91
Memory Gain Index	15.00	17.60
Consolidation index	36.50	17.99
Primacy effect	-0.36	1.50
Recency effect	0.79	3.63

Procedure

Luria´s Memory Words test-Revised is a task consisting of 10 words, read aloud with a one-second interval between each word, in ten consecutive trials. Each trial is followed by a free-recall answer and by a free estimation of recall. The words are presented in a fixed order throughout the trial. Instructions are repeated before each trial to avoid their being forgotten. After 30 minutes the subject repeats the test for one trial only. The time required for administration is 10 to 15 minutes.

Administration

The examiner must give the following instruction: "I am going to read a list of ten words that you must memorize. Listen carefully. I am going to read one word at a time but there are so many that you will not be able to remember all of the words the first time through. So, when I stop, you will have to repeat as many words as you can remember. Only try to remember as many as you can. Another important thing is that you will have to tell me how many words you think you will recall. Listen carefully: House-Forrest-Cat-Night-Table-Needle-Cake-Bell-Bridge-Cross. "Now your turn". After the first trial the examiner says: "O.K., very good, now I will read the same words again. As before, when I finish reading the words, I want you to tell me as many words as you can remember, whether or not you said them before. This time, tell me how many words you think you can recall before I tell you the words again". The list will be read for Trials 3-10 using the Trial 2 instructions.

Scoring

The scoring system follows:

1. Total Recall (TR): Total numbers of words that subject tells the examiner, including additions and repetitions.
2. Total Recall Index (TRI): = TR/10.
3. True Recall (TRR): Total number of words subject tells the examiner minus repetitions, perseverations and additions.
4. True Recall Index (TRRI): TRR/10.
5. Additions (Ad): Number of words that the subjects tell the examiner that are not on the original list.

6. Fabulation Index (FI): FI = Ad x 100/TR
7. Perseverations (Per): The repetition of the same word on, at least, two consecutive lines, whether the word is an addition or not.
8. Adherence Index (AI): AI = Per x 100/TR
9. Repetitions (Rp): Number of times that a word is repeated during each trial, independently of whether it is an addition or not.
10. Repetitions Index (RpI): RpI = Rp X 100 /TR
11. Contamination Index (ctI): ctI = FI + RpI
12. Aspiration Index (Asp): Total number of words which the subject believes he/she is capable of remembering.
13. Index of Awareness: AspI = Asp/10
14. Self-knowledge Index (SkI): Difference between the number of words that the subject believes he/she is capable of remembering and the number of words actually recalled. AspI – TRRI.
15. Index of Learning (IL 1): The average of actual words recalled in trials 8, 9, and 10 minus the average of words actually recalled in trails 4, 5, 6 and 7. IL 1: X_{try} (8,9,10) – X_{try} (4,5,6,7).
16. Index of Learning 2 (IL 2): Average actual words recalled in tries 4, 5, 6, and 7 minus the average of actual words recalled in tries 1, 2 , 3, and 4. IL 2: X_{try} (4,5,6,7) - X_{try} (1,2,3,4).
17. Index of Learning 3 (LI 3): Average of actual words recalled in tries 8, 9, and 10 minus the average of actual words recalled in tries 1, 2, 3 and 4. IL 3: X_{try} (8,9,10) - X_{try} (1,2,3,4)

    Normal Curve: LI 3 >LI 2> LI 1

18. Memory Gain: The average of actual words recalled in tries 8, 9 and 10 minus the actual words recalled in the first trial try multiplied by 10.

    MG: [(RR8 + RR9 +RR10) – RR1] x 10/ 3
19. Consolidation Index: Number of words actually coinciding in tries 8, 9 and 10 multiplied by 10.A consolidation percentage is obtained.
20. Primacy Effect: When the subject is only able to recall the first two words and is unable to retain in memory the final words. (Pe): X_{words} (1+2) - X_{words} (3+4+5+6+7+8).
21. Recency Effect: When the subject is only able to recall the last two words and cannot retain the first words in memory. (R)**:** X_{words} (9+10) - X_{words} (3+4+5+6+7+8)

Regional Cerebral Blood Flow (rCBF) procedure

In our laboratory of human neuropsychology at the University of Seville, the non-invasive technique of Xe inhalation was applied to measure the cerebral blood flow (rCBF) as was previously described by Obrist et al. (1975) Risberg (1975), and Obrist and Wilkinson (1988).

The patients inhaled a combination of Xe and air (70-100 Mbq/l) for one minute through a face-mask and a spirometric breathing system, followed by ten minutes of breathing normal air. The Xe reaches the cerebral tissue by way of the arterial blood and is cleared by the venous blood. The rate of isotope washout recorded makes up the basis for calculation of flow values. In this study the ISI-index of gray matter flow was used. The concentration of Xe was determined by a continued register of the exhaled air, while the clearing of isotopes from the brain was controlled by 32 collimated detectors covering 16 homologous regions in each hemisphere. The detectors are mounted on a helmet, assuring that each detector is in direct contact with the surface of the scalp. The detectors are mobile in order to adapt to different head sizes. Arterial pCO_2 was measured taking the concentration of CO_2 using a capnograph to correct the influence of CO_2 on the flow level. Two rCBF measurements were taken during two sessions on two different days. The quality of rCBF measurements was assured for absence of artifacts and obtaining proper values, curve fits, and estimation of end-tidal carbon dioxide levels.

Using the method of Obrist et al (1975), close attention was paid to the possible influence of artifacts in the air, including precaution for eliminating detectors contaminated by objects. The rCBF was measured in each of the seven patients, initially while resting. The subject was lying down on a bed, eyes closed and with minimal auditory stimulation. The subject was asked to relax without falling asleep.

Results

All the patients show a significant clinical hypoperfusion in the infero-posterior temporal lobe (T3L) of the brain while resting. Table 3 shows the ISI values .

Table 3
rCBF % ISI values for cerebral regional blood flow in each hemisphere. (F: Frontal, C: Central, T:Temporal, O:Occipital)

Brain areas	Left hemisphere	Right hemisphere
F1L	107.38 ± 6.34	104.80 ± 8.81
F2L	102.41 ± 5.41	105.54 ± 4.53
F3L	107.84 ± 7.96	103.17 ± 5.70
F4L	105.77 ± 5.61	106.07 ± 2.71
F5L	106.91 ± 1.86	106.33 ± 1.44
C1L	97.36 ± 5.10	99.02 ± 1.18
C2L	102.27 ± 5.30	103.89 ± 4.36
T1L	100.47 ± 6.22	99.07 ± 7.05
T2L	97.42 ± 6.35	99.38 ± 5.99
T3L	88.51 ± 5.98	90.95 ± 6.65
P1L	98.23 ± 1.67	96.46 ± 1.72
P2L	94.60 ± 3.12	95.31 ± 2.20
P3L	96.61 ± 2.88	96.46 ± 2.15
P4L	100.95 ± 3.25	99.61 ± 7.59
O1L	96.07 ± 4.79	96.58 ± 4.54
O2L	95.92 ± 7.50	96.04 ± 7.46
Total	50.33 ± 7.33	51.37 ± 5.39

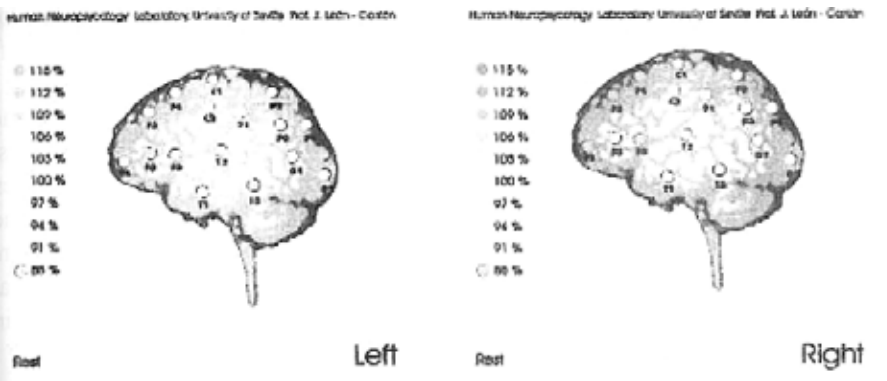

Figure 1. Representation of regional cerebral flow ISI value.

Discussion

The results show that patients with severe chronic memory deficit present an important hypoperfusion in the temporal area of the left hemisphere, especially in the inferoposterior area. This has two important implications, both theoretically and for our study. In the first place, it shows that the memory disorders affecting working memory and learning processes are related to the activation of the left cerebro-temporo-basal zone, as other authors have postulated. In addition, we find that the hypoactivation of the inferoposterior zone is most directly responsible for the patients' memory disorders.

The data show that our patients have a severe organic memory disorder, functionally at 61 %. That is, the severe and incapacitating memory deficits observed on the Luria´s Memory Words-Revised, which patients and families complain of, seem to owe to causes directly related to organic factors derived from the cerebral damage they have suffered. In this sense, our results are congruent with those obtained by Warrington and McCarthy

(1986) when they argued that deficits in word retrieval are more severe after lesions to the left temporal lobe than they are after lesions to other sections of the left hemisphere. This data also agrees with Mayes (1998), who postulates the possibility that storage and retrieval can involve a circuit made up of the left temporal cortex, frontal cortex and basal ganglia, and that within this circuit, the majority of the storage sites may lie in the left temporal cortex.

It was not possible to obtain a statistical validity coefficient for the correlation between the scores achieved on LMW-R and the rCBF measures, owing to the difficulty in finding people with normal memory test scores and rCBF measures willing to participate in the study. In our study, the criterion validity is based in the evidence that all patients with severe memory problems showed a pathological hypoperfusion in the same area: the left infero-posterior temporobasal lobe. More studies are currently in progress to validate the results presented here.

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