*Intern. J. Neuroscience*, 1989, Vol. 49, pp. 141–149
Reprints available directly from the publisher
Photocopying permitted by license only





# DETECTION OF BRAIN DAMAGE: NEUROPSYCHOLOGICAL ASSESSMENT IN A SPANISH SPEAKING POPULATION

FEGGY OSTROSKY-SOLIS and LUIS QUINTANAR

**Universidad Nacional Autonoma De Mexico*

and

ALFREDO ARDILA

***Instituto Neurologico De Colombia*

*(Received December 15, 1989; in final form April 28, 1989)*

We developed a neuropsychological battery for assessment of cognitive processes that was standarized in 150 neurologically intact subjects from different socioeducational levels in Mexico City (Ostrosky et al., 1985, 1986). The present study was designed to explore the capacity of this neuropsychological battery to discriminate a brain-injured population from a normal one. Thirty-four patients attending the neurological service of two hospitals institutions in Mexico City were studied. The reasons for going to the hospital included both neurologica and neuropsychological symptoms. The group was divided into two subgroups: twenty-four patients who showed brain damage confirmed by brain scans, and ten patients with a normal brain scan. A control group of 19 normal subjects was also studied and paired with the other groups by sex, age and sociocultural level.

The results show that the neuropsychological battery was able to recognize 83.3% of the patients with scanographically confirmed brain damage: the total percentage of successful diagnosis was 88.2% and there were no false positives. These results indicate that neuropsychological assessment is a powerful diagnostic procedure that also evaluates the patient's cognitive-behavioral activity and can help to predict the possibilities for rehabilitation and return to work.

*Keywords: Neuropsychological asessment; brain damage; Spanish speaking population; brain scan; diagnosis*

Over the past decades there has been an increased interest in the development of reliable procedures which permit a personalized, extensive, yet reliable evaluation of the type and degree of cortical functions in brain damage. In the fields of neurology and psychology there have been attempts to characterize the degree to which functions are conserved as well as to determine the functions that have been lost. A large range of procedures and techniques have been implemented such as electroencephalography, brain scanning and batteries of psycholgoical tests that have led to a great advance in both the localization of brain damage and the type and nature of the lesion. Neuropsychology has played an increasingly important role in this assessment, contributing in diagnosis, prognosis and rehabilitation programs. This has been possible due to the fact that neuropsychological assessment emphasizes the analysis fo the cognitive and the behavioral consequences of brain damage (Hecaen & Albert, 1978; Luria, 1980; Lezak, 1984).

Several authors have developed neuropsychological procedures to evaluate cognitive activity. Some emphasize the quantitative aspects (Reitan, 1973; Boll, 1981)

Feggy Ostrosky-Solis, Av. San Bernabe 641–22, Mexico 10200 D.F., Mexico

classifying subjects according to the score obtained; others evaluate not only the success or failure on a given task but also characterize performance quality (Luria, 1980; Christensen, 1979); and, finally, others attempt a quantitative and qualitiative evaluation (Golden, Purisch & Hammecke, 1978; Golden, 1981). However, all these instruments have been developed in specific linguistic and socio-cultural environments and can only be used elsewhere after a complicated process of standardization. Furthermore, there are different variables which can influence performance; for example, it has been shown that a subject's socio-cultural level affects his performance on neuropsychological tests (Benton, Levin & Van Allen, 1974; Finlayson, Johnson & Reitan, 1977; Amante et al., 1977; Ostrosky et al., 1985, 1986) and these effects become even more evident in subjects belonging to societies with a substantially different development.

The fact that Spanish speaking countries do not have sufficiently reliable standardized procedures adds further difficulty to neuropsychological practice. For example, the Luria-Nebraska battery (Golden, 1981) was used to detect brain damage in a Spanish speaking population attending the neurological service of a hospital institution in Mexico City. Results obtained were almost at a chance level, since they only achieved 45% accuracy in discriminating between a normal and a brain-damaged population (Galindo & Ibarra, 1984). Besides the need of reliable and valid instruments, transcultural comparison is interesting in itself as it adds to the analysis of brain-behavior organization.

In view of the above, Ardila, Ostrosky and Canseco (1981), using Luria's theoretical basis, developed a battery which tried to minimize as far as possible factors relevant to the social, educational and premorbid background of the patients assessed.

During the first stage of the research, performance profiles of normal subjects from different socio-cultural levels were drawn up (Ostrosky et al., 1985) and significant differences were found in the most elaborate aspects of language and in motor coordination, sequencing and programming which were favourable to subjects from a high socio-cultural level.

A second analysis (Ostrosky et al., 1986) reported an interaction between socio-cultural level and sex: performance was found to be poorer in women from a low socio-cultural level. These differences can be explained on the basis of the following hypotheses: 1) There is greater risk of damage to the nervous system in the low level (perinatal hipoxy, traumatisms, etc.) (Amante et al., 1977). 2) The differences between the socio-cultural groups are the result of different nutritional factors (Cravioto & Arrieta, 1982). 3) The differences between the socio-cultural levels are the result of the stimulation differential provided by the environment (Robinson, 1974). These hypotheses are well found and the variables involved may interact. However, the enormous weight of the sex factor (Ostrosky et al., 1986) led to the supposition that the stimulation variable (probably quantitative and qualitative) could be responsible for the differences found.

This has both theorectical and practical implications. In neuropsychological practice if we do not consider cultural, social and occupational factors we can run the risk of diagnosing pathology when we are simply observing individual differences in stimulation and learning, or, on the other hand, we could consider a pathological case to be normal.

The objective of the second stage of the research was to determine the Scheme's capacity to distinguish a damaged population from a normal one. The brain scan was used as an external contrasting criterion.

## METHOD

### *Subjects*

A total of 53 subjects were studied; 34 were patients at the neurological service of two hospital institutions in Mexico City. Sixteen of the patients were men and 18 women with an average age of 37 and 14 years of schooling. The reasons for their going to the hospital included both neurological symptoms (cephaleas, nauseas, motor loss, sensory loss, etc.) and neuropsychological ones (speech difficulties, forgetting words, mistakes in reading and writing, memory difficulties, behavioral abnormalities, etc.).

The control group comprised 19 normal subjects: 8 women and 11 men with an average age of 36 and with 17 years schooling. They were all students and professionals who functioned adequately in their environment, did not suffer from neurological damage and had no background which indicated neurological or psychiatric pathology. Their participation was voluntary. Table 1 describes the characteristics of the sample.

### *Material*

The testing material included the Neuropsychological Diagnostic Scheme (Ardila, Ostrosky, Canseco, 1981; Ardila & Ostrosky, in press) which is derived from the diagnostic procedures used by Luria (1980) and items taken from different neurological and neuropsychological tests. The Scheme explores nine different areas: I) Motor Functions, II) Somatosensory Knowledge, III) Spatial and Visuospatial Knowledge, IV) Auditory and Language Knowledge, V) Cognitive Processes, VI) Oral Language, VII) Reading, VIII) Writing and IX) Basic Calculations. Table 2 summarizes the Scheme.

### *Procedure*

The medical history of all the patients was taken down. They were all given complete neurological examinations and brain scans were taken which were interpreted by each institution's radiologist. The group was subsequently divided into two subgroups: 1) patients whose scans had proved them to have brain damage; this group totalled 24; and 2) patients whose brain scans were reported to be normal; 10 patients were included in this group. Table 3 shows the diagnostic and symptomatic subtypes of these two groups. A control group of normal subjects was then selected and was paired with the other groups by sex, age and socio-cultural level. The neuropsychological scheme was then applied on an individual basis. The length and number of working sessions were determined by each patient's advance.

## RESULTS

Figure 1 shows the performance of the three groups. The raw scores obtained by the three groups were transformed into T scores with a mean of 50 and a standard deviation of 10. We based this transformation on the performance of a previously tested sample of 150 normal subjects of different socioeducational levels in Mexico City (Ostrosky-Solis, et al., 1985, 1986).

An analysis of covariance was carried out for the 9 sections of the Scheme. Age was entered as the covariate and sex and group as factors. The differences found between

**TABLE 1**
**Descriptive characteristics of the population studied**

| Groups studied | N | Sex | | Age | | Schooling | | Laterality | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Women | Men | $\bar{X}$ | Range | $\bar{X}$ | Range | Right | Left | Amb. |
| Positive | 24 | 11 | 13 | 38.79 | 20–57 | 12.29 | 8–20 | 21 | 2 | 1 |
| Normal | 10 | 7 | 3 | 36.00 | 20–55 | 16.50 | 10–20 | 10 | – | – |
| Control | 19 | 8 | 11 | 36.27 | 28–65 | 17.57 | 13–22 | 19 | – | – |

TABLE 2
Neuropsychological Scheme. Includes 95 items from which 195 scores can be obtained and emphasizes two aspects: a) quality of the mistakes — each item is scored according to one or several criteria and not simply according to whether that subject performed the task or not; and b) a simple quantification is carried out under three categories for each criterion: 1) Normal performance; 2) Regular performance, moderately anomalous; and 3) Impossible performance. Hence, the poorer the subject's performance the higher his score.

| | |
|---|---|
| I<br>MOTOR FUNCTIONS | Includes tasks which require the coordination, reproduction and repetition of simple and complex movements with the hand, the arm and bucofacial movements. Series of alternating motor activities |
| II<br>SOMATOSENSORY KNOWLEDGE | Includes the discrimination of tactile stimuli, recognition of shapes, reproduction of hand positions and tactile memory. |
| III<br>VISUOPERCEPTUAL AND VISUOSPATIAL RECOGNITION | Explores recognition of simple and complex drawings, figure-ground discrimination, visual colsure, visual analysis and synthesis, reproduction of drawings and designs, object assembly and block designs. |
| IV<br>AUDITORY KNOWLEDGE AND LANGAUGE | Assesses the detection and discrimination of phonemes, tap-out asymetrical rhythms, retention and evocation of a list of 5 meaningless syllabes, repetition of verbal sequences and recognition of natural sounds. |
| V<br>COGNITIVE PROCESSES | Includes logical reasoning, classification of objects, understanding of analogies, picture completion and picture arrangement. |
| VI<br>ORAL LANGUAGE | Explores the production of simple and complex words, comprehension of language, verbal learning curves for bysyllabic words, immediate and delayed memory for sentences, naming of objects and body parts, complex grammatical relations and passive constructions. |
| VII<br>READING | Includes recognition of letters, syllabes and words, oral and silent reading. |
| VIII<br>WRITING | Assesses automatic writing, copy and dictation. |
| IX<br>BASIC CALCULUS | Explores mathematical notion and basic arithmetic operations. |

TABLE 3
Etiology of patients whose brain scan shows brain damage (n = 24 with positive scan) and symptoms of the patients whose brain scans were reported to be normal (n = 10 with negative scan).

| Positive brain scan N | etiology | Negative brain scan N | symptoms |
|---|---|---|---|
| 5 | Craneoencephalic traumatism | 3 | Transitory global amnesia |
| 2 | Cisticercosis | 3 | Cephalea |
| 3 | Chronic Alcoholims | 1 | Vertigo |
| 1 | Huntingtons disease | 1 | Right hemiparesia |
| 2 | Hydrocephalia | 1 | Chronic organic syndrome |
| 2 | Wernickes encephalopathy | | |
| 2 | Chronic organic syndrome | | |
| 4 | Cerbrovascular accidents | | |

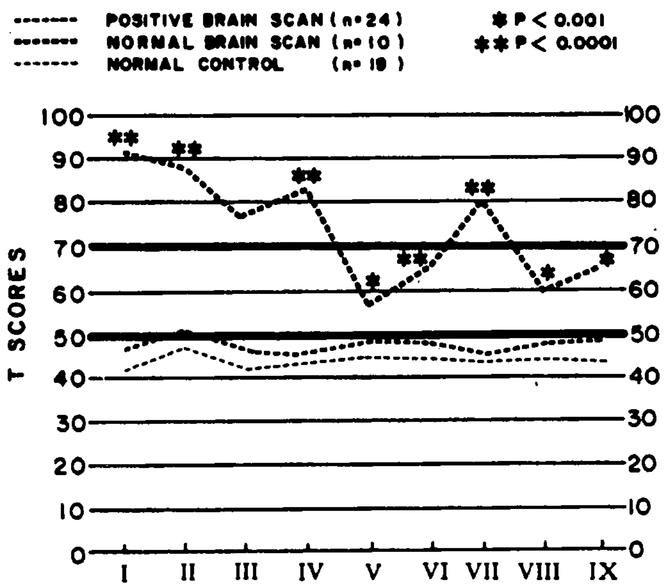


FIGURE 1 Mean scores on the neuropsychological diagnostic scheme obtained by the control group of normal subjects, patients whose scans had proved them to have brain damage and patients with a normal brain scan. No Significant differences were found between the control group and the group with normal scans and both groups were significantly different from the group with a positive brain scan. Level of significance are *$p < .001$; **$P < .0001$

I - MOTOR FUNCTIONS
II - SOMATOSENSORY KNOWLEDGE
III - VISOPERCEPTUAL AND VISUOSPATIAL RECOGNITION
IV - AUDITORY KNOWLEDGE AND LANGUAGE
V - COGNITIVE PROCESSESS
VI - ORAL LANGUAGE
VII - READING
VIII - WRITING
IX - CALCULUS

the groups were statistically significant for the nine sections of the Scheme. Figure 1 shows the average score and significance level.

An "a posteriori" analysis using Tukey's method (in Kirk, 1968) showed consistent statistically significant differences between the group proved by the scans to suffer from brain damage and the two other groups, while the differences between the control group and the group with negative scans were not statistically significant for any of the Scheme's sections. No significant differences were found for sex.

Taking the results obtained on the brain scan as an external criterion one of the patients with a negative scan obtained a T score greater than 70 (two standard deviations above average) on any of the sections in the neuropsychological examination; and vice-versa, only four of the patients with brain damage proved by the scans, obtained T scores equal to or less than 70 on any of the sections of the Scheme. This means that the neuropsychologicla examination recognized 83.3% of the patients with brain damage, and no false positives appeared on the sample used.

In Summary, the total percentage of correct diagnoses with the sample studied was 88.2% which compares very favourably with other procedures for diagnosing brain damage. A similar percentage is obtained using the brain scan, while the percentage of correct diagnoses using the angiograph is 80% (Filskov, 1974). The false positives were 0% and the false negative were 16.6%.

## DISCUSSION

The principal objective of this work was to analyze the capacity of a neuropsychological diagnostic procedure to recognize those patients, from a group attending a neurological service, who suffered from a type of brain damage which could be proved by means of a brain scan. The sample studied varied in etiology although some type of diffuse or multifocal brain damage predominated. Craneoencephalic traumatisms present some kind of wide effect which extends beyond the changes recognized by the scanned image; cisticercosis implies the presence of multiple calcifications at different levels of the nervous system; hydrocephalia can extensively affect the cortical structures as a result of ventricular dilation; in Huntington's disease the presence of choreiform movements is the result of changes in the caudate nucleus but accompanied by a demential syndrome, although it is frequent to find frontal atrophy on the scan; the scans of patients with diagnosed chronic alcoholism often show cortical atrophy; and in patient classified as suffering from chronic organic syndrome multiple infarts were found. With the exception of four patients suffering from cerebrovascular accidents, three with damage located in the area irrigated by the left middle cerebral artery, and one patient with a right hemianopsia due to involvement of the left posterior cerebral artery, all the patients included in the sample showed some type of relatively extensive cerebral involvement. The patients with a negative scan were diagnosed as having transitory global amnesia which, as was expected, does not produce any changes which can be picked up by the scan; vertigo which can result from different etiologies, not only central but peripheral as well; cephalea, which can appear in very different parts of the brain and is not necessarily the result of structural damage (such as vascular cephaleas, tensional cephaleas, etc.) and "right hemiparesia" resulting from a transient ischemic attack.

Due to the inclusion in the sample of four patients with left cerebrovascular damage in the regions irrigated by the middle and posterior cerebral arteries we expected some evident bias in the involvement of verbal functions.

Obviously, the results obtained from our sample of patients are the result of the underlying pathologies that were found.

The sample, although small, allowed for a sufficiently rigorous handling of the statistics and the statistical differences found are noteworthy. All the areas evaluated reached a level of significance of $p < .001$.

It is important to emphasize that although the majority of the tasks used are routine ones in a neuropsychological examination, all the tasks applied were previously standardized on a normal population of the same cultural group (Ostrosky et al., 1985; 1986) and in this way we believe we have controlled the previously mentioned difficulty of using the same diagnostic procedures in different cultures.

The percentage of correct diagnoses was high (88.2%) and we did not find false positives. It is probable that no known procedure can in itself eliminate the false negatives; we can only try to minimize them by combining several procedures. However, the real diagnostic errors are the false positives: when a pathology is supposed to exist but, in fact, does not. False negatives simply imply that, for the moment, with the procedure used and the prevailing conditions, it has been impossible to show the presence of pathology, not that pathology does not exist. Multiple sclerosis is a good example of this.

There is, moreover, a fundamental point which we must bear in mind when we compare different diagnostic procedures: the examination chosen depends on the proposed objectives. No clinic would suppose that the scan, in spite of its virtues, would be an examination of interest in a case of primary epilepsy. The scan recognizes structural damage to the nervous system and if the supposed pathology is of this type, the scan could prove to be the examination of choice. On the other hand, paroxystic disorders can be more easily recognized by means of electroencephalography. Furthermore, if we wish to know the vascular characteristics of the brain then the examination we choose will be neither the scan nor electroencephalography but angiography. Similarly, a neuropsychological examination has very specific particular objectives for which it will be useful.

We can state that the main objective of the neuropsychological evaluation is to find out the patient's cognitive-behavioral activity in different areas such as perception, language, memory, cognition, etc. Given his information, it also allows us: 1) to suppose the existence of possible underlying pathological processes; 2) to consider the possible topography and extension of the damage; and 3) to suggest and plan rehabilitation procedures.

Further to these points, it is possible to indicate another series of objectives: to determine the possible capacity and work situation of the patient; to establish general guidelines on the handling of the patient and the design of appropriate environments; to predict the possibilities for rehabilitation and return to work; etc. These considerations lead us to the following conclusions: 1) Correctly used and interpreted, the neuropsychological evaluation constitutes a very powerful diagnostic procedure in the hands of the expert. 2) The neuropsychological evaluation supposes a precise consideration of variables such as age, sex, laterality and the patient's level of education. 3) The neuropsychological diagnosis not only identifies the existing damage; its main objective is to evaluate the patient's cognitive-behavioral activity at that time.

## REFERENCES


Amante, D., Vanhouten, V., Grieve, J., Bader, C. & Margules, P. (1977). Neuropsychological deficits etnicity and socioeconomic status. *Journal of Consultaing and Clinical Psychology, 45,* 524–535.

Ardila, A., Ostrosky, F. & Canseco, E. (1981). *Esquema de diagnostico neuropsicologico. Colombia*: Universidad Javeriana.

Ardila, A. & Ostrosky-Solís, F. *Daño Cerebral: Un enfoque Neuropsycológico. México*: Trillas. In Press.

Benton, A., Levin, H. & Van Allen, W. (1974). Geographic orientation in patients with unilateral cerebral disease. *Neuropsychologia, 12,* 183–191.

Boll, T. (1981). the Halstead-Reitan Neuropsychological Battery. In S. Filskov & T. Boll (Eds.), *Handbook of Clinical Neuropsychology (pp. 577–607). New York*: John Wiley & Sons.

Cravioto, J. & Arrieta, R. (1982). *Nutrición. desarrollo mental. conducta v aprendizaje.* Mexico, D.I.F., U.N.I.C.E.F.

Christensen, A. (1979). *El diagnóstico neuropsicológico de Luria. Barcelona*: Ed. Juan Pablos.

Filskov, S. & Golstein, S. (1974). Diagnostic validity of the Halstead Reitan neuropsychological battery. *Journal of Consulting and Clinical Psychology, 42* 282–288.

Finlayson, M., Johnson, K. & Reitan, R. (1977). Relationship of level of education to neuropsychological measures in brain damaged and nonbrain-damaged adults. *Journal of Consulting and Clinical Psychology, 45,* 536–542.

Galindo, G. & Ibarra, R. Bateria neuropsicológica de Luria-Nebraska: un intento de validación. (1984). Unpublished Tesis. Mexico Universidad Anahuac.

Golden, C., Purisch, A. & Hammecke, T. (1978). Diagnostic validity of a standardized neuropsychological battery derived from Luria's neuropsychologicla tests. *Journal of Consulting and Clinical Psychology, 46.* 1258–1265.

Golden, C. (1981). A standardized version of Luria's neuropsychological tests. A quantitative an qualitative approach to neuropsychological evaluation. In J. Filskov & T. Boll (Eds.). *Handbook of clinical neuropsychology (pp. 608–642). New York*: John Wiley & Sons.

Hécaen, H. & Albert, M. (1978). *Human neuropsychology. New York*: Wiley.

Kirk, R. (1968). *Experimental design: rpocedures for behavioral sciences. New York:*Brooks-Cole Publishing.

Lezak, M. (1984). *Neuropsychological assessment. New York*: Plenum Press.

Luria, A. (1980). *Higher cortical functions in man.*Basic Books, Inc., Publishers. New York. Second Edition.

Ostrosky-Solis, F., Canseco, E., Quintanar, L., Navarro, E., Meneses, S., & Ardila A. (1985). Sociocultural effects in neuropsychological assessment. *International Journal of Neuroscience, 27* 53–66.

Ostrosky-Solis, F., Quintanar, L., Meneses, S., Navarro, E., Canseco, E. & Ardila, A. (1986). Actividad Cognoscitiva y nivel sociocultural. *Revista de Investigacion Clinica, 38,* 37–42.

Reitan, R. (1973). Psychological testing in neurological diagnosis. In A. Youmas (Ed.) *Neurological surgery (pp 423–440).* Philadephia, Saunders Co.

Robinson, W. (1974). Social factors and language developement in primary school children. In R. Huxley & E. Ingram (Eds.). *Language acquisition: models and methods (pp 193–221). New York*: Academic Press.