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Brief aphasia evaluation (minimum verbal performance): Concurrent and conceptual validity study in patients with unilateral cerebral lesions

NORA SILVANA VIGLIECCA[1,2], MARISA CAROLA PEÑALVA[2], SILVIA CRISTINA MOLINA[2], & JAVIER ALFREDO VOOS[3]

[1]*Consejo Nacional de Investigaciones Científicas y Técnicas de la Argentina (CONICET), Servicio de Neurología y Neurocirugía del Hospital Córdoba, Argentina,* [2]*Centro de Investigaciones de la Facultad de Filosofía y Humanidades (CIFFyH), Universidad Nacional de Córdoba (UNC), Argentina, and* [3]*Grupo de Ingeniería Clínica de la Universidad Tecnológica Nacional (UTN), Regional Córdoba, Argentina*

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Abstract

Introduction: Aphasia tests validated according to the brain injury side are necessary, especially for Spanish instruments.
Objectives: To study the concurrent validity of this Brief Aphasia Evaluation (BAE) to differentiate patients with left cerebral lesions (LC) from patients with right cerebral lesions (RC) as well as LC from healthy participants (HP). To study, through an unrestricted-sub-test-factor analysis, the BAE conceptual and content validity to generate a verbal homogeneous construct.
Materials and methods: Data were obtained from a sample of 109 right-handed volunteers: 37 LC, 34 RC and 38 HP. The three groups were matched according to gender, age and education.
Results: Both groups of patients were similar in type and site of lesion, time since onset of condition, risk factors, presence of hemianopsia and hemiparesis and number of hospital visits. The Cronbach's alpha coefficient indicated an internal consistency of 0.99 for the total score and 0.88 or above for any of the sub-tests. All sub-tests (with loadings of 0.65 or above) grouped in one factor which explained 78% of the variance. The BAE showed a sensitivity and specificity of 0.84 or above to identify the LC (median as cut-off point).
Conclusions: This test of free distribution demonstrated a satisfactory validity.

Keywords: *Aphasia screening test, dementia, differential diagnosis, methodology, predictive validity*

Introduction

Aphasia and the left hemisphere

Catani et al. [1] affirm:

> The most compelling evidence for language lateralization comes from studies of patients with language deficits after brain lesions. In right-handed adults presenting with aphasia, the brain lesion is almost invariably located in the left hemisphere. Similar prevalence data have been found in subjects undergoing brain surgery for epilepsy, with lateralization of language to the left hemisphere being observed in >90%, but not all, of the right-handed subjects. (p 17163)

Those indices are coincident with evidence collected from dichotic listening assessments in Spanish speakers [2]. Nevertheless, there is a lack of aphasia tests for Spanish speakers validated depending on the side of brain injury. In general, and beyond the language involved, aphasia tests validated according to brain injury (including side, site, type, etc.) are

Correspondence: Nora Silvana Viglieca, Luciano de Figueroa 414. B° Marqués de Sobremonte, CP: 5008, Córdoba, Argentina. Tel: +54 351 3426885. +54 3543 420877. Fax: +54 3514334061 (ext. 102). E-mail: nsviglieccа@gmail.com

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rare or incomplete. Psychometric studies have the particularity of leading to better theoretical and methodological inferences about brain and cognition.

Background

Validity. The Western Aphasia Battery (WAB) studies [3] were entirely based on psychological (not anatomical) grounds. By following the approach proposed by Shewan and Kertesz [3], the eight types of aphasias are inferred from the score ranges in four sub-tests: 'Using the fluency score and the weighted comprehension, repetition and naming scores together serves as a classification system for the type of aphasia... In general, clinical presentation as aphasic was the basis for selecting subjects for this study'. Consequently, the WAB aphasia classification can be considered as a collection of psychological empirical definitions for anatomical concepts which have just been assumed as valid. In addition, the empirical definitions are not exhaustive since the cut-off points do not consider all the possible combinations of such four symptoms. 'The classification system does not address the many patients whose symptoms are of "mixed" nature... the impetus for classification may push these patients into categories that are only partially appropriate' [4].

The use of known psychological symptoms or clusters of symptoms (i.e. the aphasia patterns) as the main variables to be described in any kind of research has been a dominant methodological characteristic of traditional aphasia studies. Notably, the anatomical causes of such aphasia patterns have not been equally described. A purely psychological approach was also used in both the short Bedside Assessment of Language (BL) for Spanish speakers [5] and the Boston Diagnostic Aphasia Examination (BDAE)-Spanish version [6]. The construct validity of the BL was demonstrated by its correlation with the WAB but, so far, a valid translation and adaptation of the WAB to Spanish speakers has not been developed. In addition, the BL control group was made up of disartric patients to whom the WAB was not administered [5]. On the other hand, in the BDAE [6], patients with typical aphasia diagnoses were apparently selected not only according to the expert clinical criterion but also according to the experimental test itself, thus probably producing a redundant and over-estimated pattern of correct classifications into the discriminant analysis. The use of typical cases can also be questioned when the presence or absence of language deficits (established by expert clinical criterion) is combined with the presence or absence of unilateral lesions and, instead of considering four categories of analysis, only two of them are *a priori* selected for studying [7]. Alternatively, the massive incorporation of patients with stroke to the sample can complicate laterality interpretations if those patients have bilateral lesions, as it usually occurs in most of those cases.

As a consequence, it was decided to study in a sample of consecutive patients with unilateral cerebral lesions of diverse aetiology their performance on the present aphasia test by the direct interaction between anatomical data and test performance. The patients were also compared with healthy participants (HP), matched according to gender, age and education so as to have a control parameter for the patients' cognitive impairment.

Factor-structure studies. Factor-structure studies analyse (a) whether the different parts of the test can be considered as components of the same psychological construct (conceptual validity) and (b) whether this psychological construct helps to explain the variance among participants (content validity).

Shewan and Kertesz [3] reported a factor analysis in which five sub-tests contributing to the so-called aphasia quotient of the WAB (which excludes gesture praxis, construction, non-verbal intelligence, writing and other sub-tests) accounted for 83% of the variance in a sample of aphasic patients. This finding was interpreted as reflecting an overall severity language measure. Pineda et al. [8] observed that seven factors were extracted by factor analysis when the comprehensive BDAE for Spanish speakers was administered to HP. Meanwhile, Goodglass and Kaplan [6] showed different numbers and types of factors when different sub-tests and factor analyses were carried out with the original test in aphasic patients.†

Considering brief aphasia tests, factor analytic studies are rare. As far as is known, the factor structure of a brief aphasia test has only been studied in the Reitan-Indiana's Aphasia Screening Examination for English language [9].

Studies from the laboratory [10] indicated that one factor solution was suitable for this Brief Aphasia Evaluation (BAE) in HP.

As a consequence, it was decided to study in the present sample of patients and HP the validity of the BAE to generate a verbal homogeneous construct through an exploratory and unrestricted sub-test-factor analysis.

† The WAB is a modification of the BDAE and many of the items are identical for both tests [3].

Objectives

To study the concurrent validity of the BAE to differentiate patients with left cerebral lesions from patients with right cerebral lesions as well as patients with left cerebral lesions from HP. To study, through an exploratory and unrestricted sub-test-factor analysis, the conceptual and content validity of the BAE to generate a verbal homogeneous construct which explains most of the variance within participants.

Material and methods

Material

The BAE was designed to quickly detect the basic resources of verbal communication (minimum verbal performance) in patients with aphasia and it was freely offered by its authors in paper, informatics and English versions [11, 12].† The BAE, which is part of the battery of 'Neuropsychological Tests Abbreviated and Adapted to Spanish-Speakers' [13, 14], is usually administered at the patient's bed-side and consists of 72 items scored from 0–3 (maximum score 216). This test counts on with satisfactory reliability coefficients [10] and the main functions to be studied by means of it are: (1) Comprehension, (2) Expression, (3) Naming, (4) Repetition, (5) Reading, (6) Writing, (7) Attention (phonemic analysis and synthesis), (8) Memory and (9) Orophonatory Praxis. The first six functions (especially the first four and, complementarily, Reading and Writing) are classically assumed as the main factors which determine the variance among patients with brain injury, thus hypothetically discriminating aphasia types. The remaining three functions were incorporated with exploratory purposes. The test duration (minutes to perform the test) and an additional sub-test which assessed personal, place and time orientation (by using auditory and visual options) were also analysed as complementary information.

Statistical analyses

Descriptive sample data were analysed by ANOVA for continuous variables or by Chi square (χ^2) for categorical variables. The internal consistency of the BAE and all its sub-tests was analysed by the standardized Cronbach's alpha coefficient. The performance based on the lesion laterality, for all the dependent variables, was analysed (with exploratory and descriptive purposes) by ANOVA and by the Newman-Keuls test for *post hoc* comparisons. An exploratory and unrestricted factor analysis (by the principal component-method) was carried out with the main nine sub-tests of this instrument. Then, the BAE performance based on the lesion laterality was analysed by the median (Mdn) test in order to examine, for the total score, not only the difference among groups but also the test sensitivity and specificity.

Participants

Data were obtained from a sample of 109 right handed volunteers: 37 patients with left cerebral lesions (LC), 34 patients with right cerebral lesions (RC) and 38 HP. The three groups were matched according to gender, age and education.

HP were community-dwellers, independent and adapted to daily life demands, without any known neurological or psychiatric disease. They were recruited from cultural, recreational and retirement centres of Cordoba province. In order to include a person in the HP sample, this study also took into consideration the information provided by an initial interview. This interview evaluated clinical antecedents, risk factors, background and their probable incidence on cognition and behaviour. Participants who showed symptoms of neurological or psychiatric disease, any kind of medical illness which could affect neuropsychological performance or sensorial or motor difficulties which could prevent them from carrying out the tests fluently were excluded.

The sample of patients was recruited from the Neurological and Neurosurgery Service of the Cordoba Hospital, a public hospital for adults. Patients with lesions in eloquent cognitive brain areas or with evident cognitive or behavioural symptoms in the neurological exam were referred by their physicians for neuropsychological diagnosis. Data were processed when a similar number of LC and RC (near 30) was reached and with the first consecutive patients of each group. The BAE was administered before the initial interview, thus blindly to both the physician (or caregiver) language reports and the side of cerebral lesions.

Lesions were confirmed by CT scan and/or MRI techniques. Most of the lesions were also confirmed by anatomopathology. All the patients had only focal and unilateral brain lesions (bilateral damage was excluded) and none of the patients suffered from any other (previous or simultaneous) neurological disease associated. Lesions were divided in hemispheric anterior (frontal) lesions (A) vs hemispheric posterior (temporal, parietal or occipital) lesions (P); as well, lesions located in inferior structures (such as thalamus, basal ganglia, internal capsule, etc.) were classified as sub-cortical (SC) lesions; and lesions

†A formal registration (with a user and a password) is required to encourage responsible use of the test.

Table I. Demographic data.

Group	Age (SD)	Education (SD)	Gender (men's frequency)	*n*
LC	50.94 (13.72)	7.84 (3.03)	18	37
RC	48.85 (15.03)	8.12 (4.04)	20	34
HP	51.74 (15.72)	8.42 (2.88)	16	38
Total	50.57 (14.76)	8.13 (3.31)	54	109
	$F(2, 106) = 0.36$, $p < 0.70$	$F(2, 106) = 0.29$, $p < 0.75$	$\chi^2 = 2.02$; df: 2; $p < 0.36$	

located in the frontal lobe and any of the posterior lobes or in regions located between the frontal lobe and the posterior lobes were classified as antero-posterior (AP) ones.

Patients who suffered from visual agnosia, who were not able to point at objects or cards or who did not have a minimum and clear comprehension and expression of affirmative and negative answers, either verbal or non-verbal, were excluded. The neuropsychological BAE did not represent any risk for the participants who, in all cases, were alert and willing to complete the BAE, independently of their relative capacity to perform some of the sub-tests or items in particular. Participants did not receive any payment for their contribution.

Ethical statements

In order to carry out this work, the participants written informed consent (or the patient's care-givers'), the approval of the Research and Ethics Committee of the Cordoba Hospital and the support of the CONICET were all collected. This study was performed pursuant to the ethical standards established in the 1964 Declaration of Helsinki [15].

Results

Sample data

Table I shows the matched demographic data for the three samples of study.

Table II shows the lesion classification based on its type and side. Malignant tumours represented the more frequent type of lesion. By grouping the cells with fewer cases (i.e. the cells which represented to the rest of the lesions) a non-significant difference between LC and RC was observed in the presence of malignant tumours vs the rest of the lesions ($\chi^2 = 0.35$; df: 1; $p < 0.55$).

Table III shows the lesion classification based on its site and side. As shown, a non-significant difference was observed between LC and RC for those four sites of lesions ($\chi^2 = 0.39$; df: 3; $p < 0.94$).

Both groups of patients did not differ either in their time since onset of condition (divided in months) (LC: 7.54 ± 18.28, RC: 11.59 ± 28.31 ($F(1, 69) = 0.52$, $p < 0.47$) or in the presence of any additional risk for cognitive impairment (malnutrition, frequent contact with toxic agents, hypertension, heart disease, obesity, diabetes, genetic component of the illness, alcohol or drug consumption, etc.) (LC: 2.16 ± 1.44, RC: 2.35 ± 1.57 ($F(1, 69) = 0.28$, $p < 0.59$). The presence of hemianopsia (LC: 11%, RC: 18%; $\chi^2 = 0.19$; df: 1; $p < 0.66$) and hemiparesis (LC: 59%, RC: 44%;

Table II. Classification of the focal cerebral lesions based on their type and side.

	Side	
Lesion type	Left	Right
AVM	1	2
SDH	1	1
BEN TU	3	3
MAL TU	20	16
ANEU	2	1
MTS	0	1
ISQ STR	4	3
HEM STR	4	4
CYST	1	2
TBI	1	1
Total	37	34
$\chi^2 = 2.46$; df: 9; $p < 0.98$		

AVM, Arterio-venous malformation; SDH, Subdural haematoma; BEN TU, Benign tumour; MAL TU, Malignant tumour; ANEU, Aneurysm; MTS, mesial temporal sclerosis; ISQ STR, Ischemic stroke; HEM STR, Haemorrhagic stroke; CYST: Brain cysts; TBI, traumatic brain injury.

Table III. Classification of the focal cerebral lesions based on their cerebral site and side.

	Side	
Lesion site	Left	Right
A	9	9
P	9	10
AP	14	11
SC	5	4
Total	37	34
$\chi^2 = 0.39$; df: 3; $p < 0.94$		

A, frontal; P, posterior (temporal, parietal or occipital); AP, antero-posterior; SC, subcortical.

Table IV. Data observed for all the BAE-dependent variables.

	Group (SD)		
Dependent variable	LC	RC	HP
Total test score*	126.08 (65.20)	205.15 (13.45)	213.50 (3.04)
Comprehension*	46.32 (17.79)	61.32 (2.43)	62.82 (0.56)
Expression*	4.57 (3.10)	8.74 (0.67)	8.82 (0.61)
Naming*	8.35 (6.23)	15.00 (0.00)	14.97 (0.16)
Repetition*	7.92 (6.17)	14.47 (0.93)	14.89 (0.31)
Reading*	34.57 (20.34)	53.88 (4.78)	56.84 (0.44)
Writing*	14.97 (11.87)	30.85 (5.15)	32.89 (0.31)
Attention*	7.22 (6.24)	16.41 (2.55)	17.05 (1.51)
Memory**	0.41 (0.72)	1.65 (0.92)	2.21 (0.96)
Orophonatory praxia*	1.76 (1.21)	2.82 (0.52)	3.00 (0.00)
Test duration**	30.32 (11.69)	22.56 (6.99)	14.08 (2.26)
Orientation**	7.32 (3.37)	10.76 (1.41)	11.97 (0.16)

* Significant differences between LC and RC, and between LC and HP.
** Significant differences between all pairwise comparisons.
Analyses carried out according to ANOVA and post-hoc Newman-Keuls's test.

$\chi^2 = 1.67$; df: 1; $p < 0.20$) as well as the number of hospitalized patients (LC: 89%, RC: 85%; $\chi^2 = 0.24$; df: 1; $p < 0.62$) was also similar for both groups.

Inferential data

The standardized Cronbach's alpha coefficient indicated an internal consistency of 0.99 for the total score and 0.88 or above for any of the sub-tests. The BAE performance based on the lesion laterality for all the dependent variables is shown in Table IV. Just for informative purposes and according to the ANOVA, all those variables produced significant differences among the three groups ($F(2, 106) \geq 27.99$, $p < 0.001$). According to the Newman-Keuls's test for *post hoc* comparisons, only Memory, Test Duration and Orientation turned out to be significantly different between any pairs of groups. The rest of the variables only produced significant differences when the LC group was compared to any of the other two groups. For all the comparisons, the patients showed a poorer performance than HP and LC showed a poorer performance than RC. On the other hand, RC and HP did not show statistically significant differences in eight of the nine BAE sub-tests.

According to the unrestricted factor analysis, all the sub-tests (with loadings of 0.65 or above) grouped in one factor which explained 78% of the variance in the whole sample. Results did not change when HP were excluded, i.e. in pooled patients, all the sub-tests (with loadings of 0.63 or above and the same output-pattern) grouped in one unrestricted factor which explained 76% of the variance. Results were also similar when HP and RC were excluded, i.e. in the LC alone, all the sub-tests (with loadings of 0.42 or above and the same output-pattern) grouped in one unrestricted factor which explained 67% of the variance. Factor analyses could not be carried out for HP or RC alone due to the fact that some sub-tests showed no variance. The sub-tests with the lowest loadings in any of the analyses were Memory and, subsequently, Orophonatory Praxis. They showed loadings of 0.65 and 0.85, respectively, when the whole sample was analysed.

The distributions of frequencies according to the common median for the three sample pairwise comparisons are shown in Tables V–VII. As shown, all the comparisons turned out to be statistically significant, thus indicating a positive association between cerebral lesions and cognitive impairment. LC showed the poorest performance in the total BAE score. By taking the common median as cut-off point, the BAE showed a sensitivity and specificity of 0.84 and 0.85 when LP group was compared to RP and of 0.95 and 0.92 when LP was compared to HP. Those indices were lower (sensitivity: 0.76; specificity: 0.63) when the RP was compared to HP.

Conclusion

The present results demonstrated that the BAE represented a homogeneous verbal construct and a valid neuropsychological instrument to significantly differentiate LC from both RC and HP. This brief aphasia test proved to be a valid neuropsychological instrument to detect lesions of the left hemisphere (the verbal dominant one) in the present sample of Spanish speaker right-handed participants.

Table V. Distribution of frequencies according to the common median for LC and RC in the total score of the Brief Aphasia Evaluation.

Sample	Median ≤	Median >	Total
LC	31	6	37
RC	5	29	34
Total	36	35	71

$\chi^2 = 33.83$; df: 1; $p < 0.001$ (Overall median: 196).
LC, patients with left cerebral lesions; RC, patients with right cerebral lesions.
Sensitivity 0.84; Specificity 0.85.

Table VI. Distribution of frequencies according to the common median for LC and HP in the total score of the Brief Aphasia Evaluation.

Sample	Median ≤	Median >	Total
LC	35	2	37
HP	3	35	38
Total	38	37	75

$\chi^2 = 56.38$; df: 1; $p < 0.001$ (Overall median: 208).
LC, patients with left cerebral lesions; HP, healthy participants.
Sensitivity 0.95; Specificity 0.92.

Table VII. Distribution of frequencies according to the common median for RC and HP in the total score of the Brief Aphasia Evaluation.

Sample	Median ≤	Median >	Total
RC	26	8	34
HP	14	24	38
Total	40	32	72

$\chi^2 = 11.41$; df: 1; $p < 0.001$ (Overall median: 213).
RC, patients with left cerebral lesions; HP, healthy participants.
Sensitivity 0.76; Specificity 0.63.

Discussion

The present results are coincident with those of Kostalova et al. [7] and Kertesz and Poole [16], although in such cases the authors intentionally excluded patients with no aphasia and left hemisphere lesions as well as patients with aphasia and right hemisphere lesions from the experimental and control groups, respectively.

The present aphasia test represented a homogeneous verbal construct as demonstrated by both its high internal consistency and the extraction of only one factor in the unrestricted sub-test-factor analysis. This homogeneity was demonstrated not only in the whole sample but also in pooled patients and LC.

Williams and Shane [9] reported two major factors (a general language ability factor and a sensorimotor co-ordination factor) for the Reitan-Indiana Aphasia Screening Examination. Nevertheless, and unlike the BAE, the Reitan-Indiana Aphasia Screening Test also includes non-verbal tasks. Alternatively, and in agreement with the aphasia quotient of the WAB [3], a general and dominant language dimension mainly associated to severity of impairment has been frequently proposed as an explanation of factor analytic aphasia studies [17–19].

The wide range of the total BAE score, the homogeneity of the construct and the differences observed in all the studied groups suggest that the BAE can be useful to detect not only the presence or absence of aphasia, but also the severity of impairment. Considering its test–re-test reliability in HP [10] the BAE can as well be useful to analyse the patient's evolution.

The BAE turned out to be also a potential instrument to differentiate RC from HP, this finding being consistent with the one reported by Nakase-Thompson et al. [20] for the Mississippi aphasia screening test. However, in the present study, the particular difference observed between RC and HP was obtained with a minor specificity and at a lower level of significance than the differences observed between LC and the other two groups. Considering all the dependent variables, the RC-pattern of response was also clearly different from the LC one.

As regards the five functions incorporated with either exploratory purposes or complementary information, it is worth noting that Memory, Test Duration and Orientation turned out to be valid measures to differentiate all pairs of groups. Besides, as much as Attention as Memory and Orophonatory Praxis turned out to be essential components of the test as indicated by the differences observed between LC and the other two groups and factor analysis.

Orophonatory Praxis (measured by the imitation of a mouth movement made by the interviewer) and Attention (measured by the tasks of spelling, reversed spelling and phonemic discrimination and synthesis) were similar for RC and HP, thus suggesting that these kinds of tasks (with an important verbal component) might not always be useful to detect right hemisphere injured patients. On the contrary, the failures in orientation tasks (which are always composed by verbal questions and answers) may turn out to be unintentionally biased towards the detection of left hemisphere injured patients. As a consequence and taking into account the information provided by personal, place and time orientation sub-tests, many patients could be diagnosed as suffering, for example, from dementia when in fact they may only be suffering from language disturbances.

Many of the BAE items are shared by mental status screening tests but, as the BAE was specially designed to diagnose patients with language impairment, the possibility of misdiagnosis is weakened because those patients are evaluated in a more appropriate neuropsychological context.

Finally, further research would be necessary to see if the present results can be generalized to other samples and situations considering that this sample of study consisted of consecutive volunteers, including a great number of hospitalized patients.

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