received 29 March 2021 | accepted 5 November 2021 | published 3 March 2022

Doi:10.31157/an.v27i1.298

Validation and standardization of neuropsychological tests for the evaluation of praxias and gnosias in university students (Evaluation of praxias and gnosias)

Puerta-Lopera Isabel Cristina[1] | Dussán-Lubert Carmen [2] | Montoya-Londoño Diana Marcela [3]
Landínez-Martínez Daniel [4] | Pérez-Parra Julio Ernesto [5]

1. Vicerrectora de investigaciones, Universidad Católica Luis Amigó, Colombia.
2. Department of Mathematics, University of Caldas, Colombia.
3. Department of Educational Studies, University of Caldas, Colombia.
4. Catholic University Luis Amigó and University of Manizales, Colombia.
5. Department of Human Movement, Autonomous University of Manizales, Colombia.

Correspondence

Julio Ernesto Pérez-Parra
Department of Human Movement, Autonomous University of Manizales, Colombia.

jeperez@autonoma.edu.co

Abstract

Introduction: Most specialized literature focuses on the study of cognitive functions regarding brain injuries, which can relate to why praxias and gnosias are rarely discussed from a normality perspective. Objective: This article describes the results from a validation and standardization study of tests for the evaluation of praxias and gnosias.
Material and methods: 208 healthy university students were evaluated. The following tests were validated and standardized: Rey–Osterrieth Complex Figure Test (copy) and visual retention test, visual discrimination and orientation judgment (Benton test). The following tests and analyzes were performed: appearance validity (expert judgment), content validity (factor analysis), concurrent criterion validity (correlation coefficient), internal consistency (Omega coefficients) and intra- and inter-rater reliability (proportion of correct answers, correlation coefficient and comparison of paired medians).
Results: Adequate content validity was evidenced in all tests; adequate criterion validity in praxis evaluation measures; low criterion validity, internal consistency and test – retest reliability for gnosias and praxias tests. Conclusions: It is advisable to use the most appropriate test according the cultural context in which it is applied, as well as standardized instruments for the target population.

Key words: *praxias, gnosias, young adult, neuropsychological tests, reproducibility of results, reference standards.*

Introduction

Mental functions are complex functional systems, not located in restricted areas of the cortex or in isolated cell groups, but organized in systems of areas that work in concert. Each of these areas plays a role within the complex functional system, and can be located in completely different regions in the brain, very distant from each other;[1] these systems represent the basis of gnosias and praxias. The terms gnosis and praxia were first introduced by Ludwig Edinger, a German neurologist considered the founder of neuroanatomy, and were later adopted by Hugo Liepmann in the psychological description of agnosia and apraxia.[2]

Luria had previously stated that, in the case of gnosis, the main contribution is made by the Second Functional Unit of the brain, whose primary function is the reception, analysis and storage of information.[3] This unit is located in the lateral regions of the neocortex, on the convex surface of the hemispheres, of which it occupies the posterior regions, including the visual (occipital), auditory (temporal), and general sensory (parietal) regions. From this perspective, gnosis is defined as the ability to recognize a stimulus, regardless of whether the sensation of it is adequate; consequently, it represents the ability to transform sensation into perception.[4] Considering this, in a diagnosis of agnosia, although a subject can see, hear and feel, they cannot recognize visual, auditory or tactile stimuli. Furthermore, it is not possible to speak of gnosis without a related cognitive ability, praxis. These constitute the ability to carry out a programmed and organized movement with a specific purpose in a defined sequence, and to execute it in an intentional and coordinated manner.[5] It could be affirmed that there is no praxis without gnosis, that is, there is no intentional, adapted, effective and efficient execution of an action without the previous or simultaneous mental representation of it. Praxias are then considered a complex integrative process between the knowledge of something and its representation, and the corresponding actions, so that they are adequate and efficient for its adaptive exteriorization.[6]

According to recent studies, in the Colombian context, Ardila et al. standardized the Rey-Osterrieth Complex Figure Test for the evaluation of gnosis and praxis through two normative studies.7 In the first one, the influence of the educational level of the participants was considered: the test was applied to two groups of 100 different subjects (schooled and non-schooled). Subsequently, the subjects were divided by gender and age into five age ranges: 16-25, 26-35, 36-45, 46-55, 56-65. In the second, the influence of age on test performance was analyzed. In this study, 346 subjects over 55 years of age (with and without brain damage) were included. In this standardization, normative data were presented for each of the tests according to age, years of schooling and differences by sex. In addition, results of the population with brain damage were integrated.[7]

Also noteworthy is the Child Neuropsychological Evaluation (ENI) standardization,[8] carried out with children between 5 and 16 years of age in Mexico and Colombia, in which tasks related to visual-constructive skills – that included figure, complex figure and human figure copying – were created and standardized. Regarding visual perception, tasks of superimposed images, blurred images, visual closure, and integration of objects were performed. Pertainig spatial abilities, tasks of right-left comprehension and expression, drawing from different angles, orientation of lines and location of coordinates were carried out. Norms for each task according to age range were presented.[8]

Another study, carried out with 141 children from Bucaramanga (Colombia) of both sexes, between 9 and 16 years old,[9] standardized the Benton Visual Retention and Judgement of Line Orientation tests and the Rey-Osterrieth Complex Figure Test (Copy score). The analysis by age was presented according to two groups, the first from 9 to 12 years old, and the second from 13 to 16. Normative data were reported according to age, education level, and sex.

Neuronorma[10] project estudied a sample of 179 normal subjects and obtained normative data on the Spanish population between 18 and 49 years of age. Neuropsychological tests of widespread use were applied: Benton Judgement of Line Orientation, Rey-Osterrieth Complex Figure and some subtests from the Visual Object and Space Perception Battery (VOSP). Demographic features and sociocultural characteristics were recorded and normative data by age, education level and gender were described.[10]

More recently, a neuropsychology research carried out in Colombia with 1425 healthy adults standardized the Rey-Osterrieth Complex Figure Test. Normative data was established according to age, educational level, and sex.[11]

The standardization of neuropsychological and psychological tests, adapted to age ranges, and sociocultural contexts, is essential to more precisely characterize the target population. In this research, the university population was characterized in terms of their cognitive functioning, with the objective of having accurate normative data for the elaboration of descriptive profiles of cognitive functioning of said population in urban environment, which will lead to the design of evaluation proposals and intervention actions relevant to the specific characteristics of the context of the young people evaluated.

In 2021, Manizales, Colombia, was a university town of 450,074 inhabitants, of whom 76,251 were between the ages of 16 and 26 (17% of the population).[12] The city had a university population of 61,662 students, 84% of them enrolled in face-to-face mode and 83% in undergraduate programs; which averages eleven university students for every 100 inhabitants.[13] These figures highlight the importance of the neuropsychological characterization of the population under study in said context.

The objective of this research was to validate and standardize the following tests in university students between 16 and 26 years of age in the city of Manizales, Colombia: the Rey-Osterrieth Complex Figure Test, and Benton Visual Retention, Visual Form Discrimination and Judgement of Line Orientation tests.

Material and methods

This study is part of a macroproject, in which other neuropsychological functions tests were validated and standardized for the same population – such as attention, language, memory and self-concept –[14-17] and it was approved by the University of Caldas, Colombia (code 0201712), following the guidelines of Resolution 8430 of 1993 of the Colombian Ministry of Health, which establishes the scientific, technical, and administrative standards for health research.

Sample

A validation study was carried out with 208 student volunteers from the University of Caldas and the University of Manizales, Colombia, with a mean age of 21 years (SD 2.8 years). The following inclusion criteria were applied: age between 16 and 26 years, absence of neurological or psychiatric alterations or school failure; and manifestation of informed consent. Volunteers were excluded for any of the following criteria: neurodevelopmental disorders; clinical history with signs and symptoms of focal or diffuse cognitive impairment; history of central nervous system diseases with neuropsychological difficulties; perceptual disorders – visual, auditory and/or motor – that could affect the neuropsychological evaluation; presence of uncontrolled acute or chronic systemic diseases that interfere with the neuropsychological evaluation; a history of alcohol or drug abuse in the last 5 years, and a history or presence of a major psychiatric disorder. Calculation of the sample size. For the correlational analysis tests (concurrent validity and intra- and inter-rater reliability), the Hernández-Sampieri et al. (2010) criterion was applied for a minimum correlation expected of 0.21,[18] with a confidence level of 95%, and a statistical power of 85%, for a minimum sample of 201 participants.

For the reliability tests, 7 participants were assigned for each item, taking as reference the instruments with the most items: Benton Visual Retention Test (30 designs) and Benton Judgement of Line Orientation Test (30 stimuli), for a calculated sample of 210 participants.

Instruments

a. Rey-Osterrieth Complex Figure Test: it was developed by Rey and Osterrieth,[19,20] and translated into English by Corwin and Bylsma.[21] It assesses a wide variety of cognitive processes, including planning, organizational skills, problem-solving strategies, as well as perceptual and motor functions, and episodic memory.[22-25] It consists of 18 items.

b. Benton Visual Retention Test: it is an individually administered test for people eight years of age and older, which evaluates visual perception, visual memory and visuo-constructional abilities. It is made up of 3 sets or forms of 10 designs (8,5×5,5 inches) that measure the examinee's visual and memory abilities, as well as a set of alternative designs for repeated tests. The examinee is given a booklet containing 10 blank pages on which designs are reproduced. There are two forms of administration for this test: through drawing or multiple choice answers. The drawing option contains 3 alternate forms (C, D and E). Each one is made up of 10 designs; the first two consist of a geometric figure, and the rest of two main figures and one smaller figure. There are four main types of administration. In Administration Type A, which is the most standardized type, each design is presented for 10 seconds and then removed, immediately after the subject is asked to reproduce the drawing from memory on a sheet of paper at their own pace. Administration Type B is similar to Administration Type A except that each pattern is presented for only 5 seconds. Administration Type C (Copy) requires the subject to copy each of the designs without removing the stimulus from view. In Administration Type D each design is presented for 10 seconds and the subject must reproduce it after a 15-second delay. In the present investigation, the Administration Type A was used.[26,27]

c. Benton Judgment of Line Orientation Test: This is a 30-stimulus test that assesses visuospatial perception through the comparison of spatial relationships between line segments[28-29]. For each item the subject is asked to match a pair of lines with two of eleven lines presented in a semicircular model.29 Score is based on the sum of items in which there was a correct answer for both lines.[27]

d. Visual Form Discrimination Test: it is a brief test consisting of 16 multiple-choice items,[28] which involves the abilities of scanning and complex visual discrimination, but not memory.[30] Participants must maintain their visual attention throught a search process.[28] Each section of the test consists of a multiple response stimulus with 4 options, each of them containing two main figures and a smaller one. The four stimuli indicate: **1**. correct reproduction of the original figure (correct); **2**. rotation (displacement) of the figure (error pattern); **3**. rotation of the main figure; or **4**. distortion of the main figure. Total score is obtained by assigning two points for each correct answer and one point in case there is a peripheral error; other types of errors get cero points. The maximum score is 32 points.

Analysis plan

- Normality of the data was confirmed by a Shapiro Wilk test.
- Face validity: five experts in neuropsychology were consulted, using a consensus methodology. The previously selected instruments and tests were submitted for discussion.
- Content validity: factor analysis of principal components was conducted with rotation oblimin with Kaiser and maximum number of interactions for convergence 25. Sample adequacy conditions (KMO=.85) and sphericity $p<.0001$) were satisfactorily met. The tests were applied to a group of 50 people to determine correct understanding, rectify language difficulties and establish standard application and scoring criteria.
- Concurrent criterion validity: Spearman's correlation coefficient was used, since variables were not normally distributed. The performance of the students in TFCRO, TRVB, TOLB and TDVB was compared against the one showed in different criterion tasks taken from the Neuropsi Battery,[31] and some subtests of the Neuropsychological Assessment Battery for adults (NAB).[32] In the case of the TFCRO copy,[15] the coding task was used as a criterion – visuospatial process complex figure coping.[31] For the TRVB, TOLB and TDVB tasks, the subtests of perception and spatial orientation of the visuospatial area evaluation from the Neuropsychological Assessment Battery for adults (NAB) were used as criterion tasks.[32]
- Internal consistency was determined with the Omega coefficient.
- Intra- and inter-rater reliability: consistency related to the application time (test-retest) and the application by different evaluators. The Wilcoxon test for paired medians and Spearman's rank correlation coefficient were carried out using correct answers proportion. In the case of intra-rater reliability, 50 of the 208 students were randomly selected and took the test again 4 months later.
- The percentage of correct answers (pre and post) for each item was obtained using the binomial proportion p. A difference between responses of up to 20% was established as acceptable. Additionally, the pre-test and post-test results were compared using the Wilcoxon test for paired medians and Spearman's rank correlation coefficient.
- Scales for each of the tests: normative data for each of the tests were calculated. Direct scores and percentiles are presented. First, normality of the data was established and, subsequently, it was analized if there was a difference in the mean responses according to gender (using the Student's t-test or the Mann–Whitney U). No differences were found in most of the tasks to evaluate praxis and gnosis, with the exception of TOLB. As a result, only for this variable, a scale broken down by gender is shown.

Results

Face validity. The five experts in neuropsychology agreed on the usefulness and relevance of the preselected instruments and tests according to the stated objective, for which the following instruments with their corresponding tasks and items were used:

Praxias:
Rey-Osterrieth Complex Figure Test - TFCRO
-Copy score - TFCRO PC
-Copy time - TFCRO TC
-Memory time - TFCRO TM
-Deferred average score - TFCRO PMD
Gnosias:
Benton Visual Discrimination Test - TDVB
-Total score - TDVB TP
Benton Judgment of Line Orientation Test - TOLB
- Total correct answers - TOLB TC
Benton Visual Retention Test - TRVB
-Form C - TRVB FC
-Form D - TRVB FD
-Form E - TRVB FE
-Total correct answers - TRVB TRC

Content validity. Factor analysis of principal components was performed; in the case of gnosis, the first two factorial axes retain 64.2% of total variance and TRVB saturates the first axis, while TOLB does so in the second axis (Table 1).

In the case of praxis, it was again found that the first two factors explained 62.9% of the total variance and that the copy score and deferred memory score explained axis 2, in turn, deferred memory and memory times explain the first axis (Table 1).

Concurrent criterion validity. With the exception of TFCRO vs. coding (praxias), no significant correlations were found between the tests evaluated and the batteries taken as reference (Table 2).

Internal consistency. Table 3 shows adequate Omega coefficients for the tasks of cognitive processes of praxis and gnosis, with greater homogeneity in the latter.

Intra-rater reliability (test–retest). The percentage of correct answers showed agreement greater than 60% in most of the evaluated items, which indicates that the results of the scales applied at different times remain stable. In most subtests, the differences between medians and correlations were statistically significant, indicating adequate test-retest agreement or intra-rater reliability (Table 4).

Table 1. Factor saturation for content validity

Process	Item	Factor 1	Factor 2
Gnosias	TDVB TP	0,011	0,845
	TRVB FC	0,766	-0,161
	TRVB FD	0,688	-0,005
	TRVB FE	0,744	-0,026
	TRVB TRC	0,991	-0,081
	TOLB TC	0,347	0,625
	% explained variance	**45,2**	**19,0**
	% cumulative variance	**45,2**	**64,2**
Praxias	TFCRO PC	-0,297	-0,684
	TFCRO TC	-0,818	0,245
	TFCRO TM	-0,814	0,250
	TFCRO PMD	-0,315	-0,640
	% explained variance	**37,9**	**37,9**
	% cumulative variance	**25,0**	**62,9**

Abbreviations. **TDVP**: Benton Visual Discrimination Test; **TRVB**: Benton Visual Retention Test; **TOLB**: Benton Judgment of Line Orientation Test; **TFCRO**: Rey-Osterrieth Complex Figure Test; **TP**: Total score; **FC**: Form C; **FD**: Form D; **FE**: Form E; **TRC**: Total correct answers; **TC**: Total correctas; **PC**: Copy score; **TC**: Copy time; **TM**: Memory time; **PMD**: Deferred average score.

Table 2. Correlation coefficients for concurrent criterion validity

Process	Crossed items	Spearman	pValue
Gnosias	TDVB TP – Visuospatial area. Visual perception	-0,172	0,232
	TOLB TC – Visuospatial area. Visual perception	-0,083	0,566
	TRVB FC – Visuospatial area. Visual perception	-0,002	0,991
	TRVB FD – Visuospatial area. Visual perception	-0,053	0,712
	TRVB FE – Visuospatial area. Visual perception	0,053	0,713
	TRVB TRC – Visuospatial area. Visual perception	0,064	0,657
	TDVB TP – Spatial orientation	-0,017	0,906
	TOLB TC – Spatial orientation	0,161	0,263
	TRVB FC – Spatial orientation	0,122	0,396
	TRVB FD – Spatial orientation	0,233	0,103
	TRVB FE – Spatial orientation	0,191	0,183
	TRVB TRC - Spatial orientation	0,261	0,068
Praxias	TFCRO PC - Codification	0,296	0,037
	TFCRO TC - Codification	0,022	0,880

Abbreviations. **TDVP**: Benton Visual Discrimination Test; **TRVB**: Benton Visual Retention Test; **TOLB**: Benton Judgment of Line Orientation Test; **TFCRO**: Rey-Osterrieth Complex Figure Test; **TP**: Total score; **FC**: Form C; **FD**: Form D; **FE**: Form E; **TRC**: Total correct answers; **TC**: Total correctas; **PC**: Copy score; **TC**: Copy time; **TM**: Memory time; **PMD**: Deferred average score.

Table 3. Omega coefficient for internal consistency

Process	Item	Coefficient value
Gnosias	TDVB TP, TOLB TC, TRVB FC, TRVB FD, TRVB FE, TRVB TRC	0,79
Praxias	TFCRO PC, TFCRO TC, TFCRO TM, TFCRO PMD	0,67

Abbreviations. **TDVP**: Benton Visual Discrimination Test; **TRVB**: Benton Visual Retention Test; **TOLB**: Benton Judgment of Line Orientation Test; **TFCRO**: Rey-Osterrieth Complex Figure Test; **TP**: Total score; **FC**: Form C; **FD**: Form D; **FE**: Form E; **TRC**: Total correct answers; **TC**: Total correctas; **PC**: Copy score; **TC**: Copy time; **TM**: Memory time; **PMD**: Deferred average score.

Table 4. Test–retest agreement for intra-rater reliability

Cognitive process	Item	Hit percentage	pValue median difference	Spearman correlation coefficient	pValue coefficient
Gnosias	TDVB TP	0,68	0,109	0,389	<0,01
	TRVB FC	0,80	0,000	0,058	0,695
	TRVB FD	0,80	0,004	0,283	0,052
	TRVB FE	0,78	0,340	0,168	0,253
	TRVB TRC	0,76	0,007	0,235	0,099
	TOLB FH	0,80	0,001	0,579	<0,01
Praxias	TFCRO PC	0,66	0,662	0,195	0,174
	TFCRO TC	0,24	0,001	0,451	<0,01
	TFCRO TM	0,60	0,253	0,430	<0,01
	TFCRO PMD	0,78	0,000	0,105	0,467

Abbreviations. **TDVP**: Benton Visual Discrimination Test; **TRVB**: Benton Visual Retention Test; **TOLB**: Benton Judgment of Line Orientation Test; **TFCRO**: Rey-Osterrieth Complex Figure Test; **TP**: Total score; **FC**: Form C; **FD**: Form D; **FE**: Form E; **TRC**: Total correct answers; **TC**: Total correctas; **PC**: Copy score; **TC**: Copy time; **TM**: Memory time; **PMD**: Deferred average score.

Inter-evaluator reliability (application by different evaluators). All tests showed high concordance between evaluators, which indicates equivalence in the measurements by different evaluators; although in TOLB medians show divergent measurements (Table 5).

Table 5. Reliability related to the application by different evaluators (inter-rater reliability)

Cognitive process	Two evaluators	Hit percentage	pValue median difference	Spearman correlation coefficient	pValue coefficient
Gnosias	TDVB TP	0,977	1,000	0,995	0,000
	TRVB FC	0,849	0,000	0,912	0,000
	TRVB FD	0,822	0,000	0,929	0,000
	TRVB FE	0,826	0,000	0,913	0,000
	TRVB TRC	0,730	0,000	0,942	0,000
	TOLB FH	0,973	0,152	0,992	0,000
	TOLB FV	0,977	0,506	0,996	0,000
	TOLB TC	0,954	0,134	0,997	0,000
Praxias	TFCRO PC	0,931	0,533	0,833	0,000
	TFCRO TC	0,969	0,782	1,000	0,000
	TFCRO TM	0,958	0,488	0,956	0,000
	TFCRO PMD	0,865	0,231	0,451	0,000

Abbreviations. **TDVP**: Benton Visual Discrimination Test; **TRVB**: Benton Visual Retention Test; **TOLB**: Benton Judgment of Line Orientation Test; **TFCRO**: Rey-Osterrieth Complex Figure Test; **TP**: Total score; **FC**: Form C; **FD**: Form D; **FE**: Form E; **TRC**: Total correct answers; **TC**: Total corrects; **PC**: Copy score; **TC**: Copy time; **TM**: Memory time; **PMD**: Deferred average score.

Scales. Tables 6 and Table 7 show normative data for the population studied: direct scores and percentiles. There were no significant ceiling or floor effects that required further analysis. As mentioned in the methods section, only the TOLB-Copy Time test is presented by gender, since no significant differences were found in any other tests (p>0.050).

Table 6. Rey's Complex Figure Test and Benton's Visual Shape Discrimination Test. Direct scores and percentiles for university students between 16 and 26 years old

Percentile	Direct scoring				
	TFCRO PC	TFCRO TC	TFCRO TM	TFCRO PMD	TDVB TP
99	36	370	269	36	-
95	36	255	187	34	-
90	36	193	168	33	-
85	36	171	152	32	-
80	36	153	147	30	-
75	36	138	138	30	32
70	36	133	131	28	31
65	36	125	124	27	-
60	36	120	117	27	-
55	36	115	111	26	-
50	36	112	106	26	30
45	35	108	102	25	-
40	35	100	98	24	29
35	35	98	94	23	-
30	35	94	88	22	28
25	34	90	84	21	27
20	34	87	79	20	-
15	33	84	70	20	26
10	32	77	62	18	24
5	31	61	54	16	22
1	28	49	36	10	17
N	208	208	208	208	207
Media	34,8	126,7	115,5	26,4	28,7
Standard deviation	1,9	63,5	59,1	16,9	3,4

Abbreviations. **TFCRO**: Rey-Osterrieth Complex Figure Test; **TDVP**: Benton Visual Discrimination Test; **PC**: Copy score; **TC**: Total corrects; **TC**: Copy time; **TM**: Memory time; **PMD**: Deferred average score; **TP**: Total score.

Table 7. Benton's Visual Retention Test (TRVB) and Benton's Line Orientation Judgment Test (TOLB). Direct scores and percentiles for university students between 16 and 26 years old

Percentile	Direct scores					
	TRVB Forma C	TRVB Forma D	TRVB Forma E	TRVB Total correct answers	TOLB TC	TOLB TC Hombres
99	-	-	-	30	56	60
95	-	-	-	29	55	58
90	10	-	-	-	54	56
85	-	10	-	28	53	56
80	-	-	-	-	52	55
75	-	-	-	27	51	54
70	-	9	10	-	50	52
65	9	-	-	26	49	52
60	-	-	-	-	48	51
55	-	-	-	-	47	50
50	-	-	-	25	46	49
45	-	8	9	-	45	48
40	8	-	-	24	43	48
35	-	-	-	23	43	47
30	-	-	-	-	41	47
25	-	7	8	22	40	45
20	7	-	-	21	39	42
15	-	6	7	-	35	41
10	6	-	-	20	33	39
5	5	5	6	18	30	36
1	4	4	4	15	24	30
N	208	208	208	208	125	83
Media	7,9	7,7	8,4	24,0	46,1	48,5
Standard deviation	1,5	1,7	1,5	3,4	8,3	6,9

Abbreviations. **TRVB**: Benton Visual Retention Test; **TOLB**: Benton Judgment of Line Orientation Test; **TP**: Total score; **TC**: Copy time

Discussion

Praxias and gnosis are probably among the least studied cognitive functions, this is perhaps due to the fact that the specialized literature focuses on their study only in the case of brain injuries and not from a normal perspective, as well as the wide repercussion these alterations have in the development of reading, writing and mathematical processes, in addition to some types of dementia, among which frontotemporal dementia stands out.[37,38]

The term praxia refers to a system of coordinated movements articulated to achieve an objective, which are characterized for being sequential, learned and not instinctive or reflexive. According to this perspective, the term apraxia refers to the detected deficit in making voluntary movements associated with objects in the absence of paralysis. Moreover, apraxia has been traditionally defined as a difficulty in executing learned gestural skills or motor acts despite the preservation of motor and sensory systems, coordination, comprehension, as well as adequate collaboration.[39,40] Currently, it is considered as any acquired deficit of motor skills in the absence of motor alterations, which occurs as a result of neurological dysfunction.[39,40]

Gnosias refer to the sensory-perceptive recognition capacity that involves different inputs (visual, auditory, tactile, and gustatory). In turn, agnosias are defined as the inability to consciously recognize sensory stimuli of a certain type, that cannot be attributed to a sensitive alteration, nor to a verbal or intellectual deterioration.[37] The union of manual praxias and visuospatial gnosic aspects determine the formation of constructive praxias.

In terms of assessed praxias, results show adequate content validity, concurrent criterion and reliability related to test application by different evaluators; as well as adequate content validity and reliability related to the application by different evaluators in the case of gnosis.

Gnostic tasks have adequate content validity. These tasks were grouped into two factors, one derived from the TRVB, which represented a measure of visual perception, visual memory, and visuo-constructive abilities that saturated the first axis. The second axis was represented by the TRVB and TOLB measurements, which suggested the presence of a second factor that gatheres the ability for visual scanning, complex visual discrimination, and the ability to establish spatial relationships between lines segments by visual confrontation – as measures of visuospatial perception. These results coincide with that indicated in other factorial analyses, which have revealed that TRVB, for example, is based mainly on a visuoperceptual motor factor, and secondarily, on a factor of attention, concentration, and memory.[41] A second factor analysis study found that said test is based on two factors: alertness and psychomotor speed. [42]

In the case of praxis assessment tasks, it was found that two factors explained 62.9% of the total variance, indicating a representative first factor of the functions of simultaneous perception, visuospatial ability, visuo-constructive praxia and non-verbal memory, ability to pay attention to details and ability to organize the perception of complex visual stimuli. In a second factor, the measures of copy time and deferred memory time were grouped.

In relation to the validity of the concurrent criterion, significant correlations were evidenced for the case of the measures included to evaluate praxis, such as TFCRO. This result is consistent with other research indicating that visuomotor skill and memory contribute to performance on tasks with similar cognitive demands.[28] Another study with patients with neurological impairments found that complex figure scores correlated well with other tasks that required viso-constructive and memory skills like TRVB.[23,24]

Concurrent criterion validity was not evidenced for the tasks that assess gnosias, despite the fact that theoretically both groups of tests measure the same construct. In the case of the TDVB, TDOB and TRVB tasks, some subtests of the DNI battery of visuospatial area were used as criterion tasks, among which were the visual perception subtest and the spatial orientation subtest. These criterion tasks share the object of evaluation with the standardized tests, as both groups of tasks evaluate the visuospatial cognitive domain, which include the ability to handle coordinates and spatial syntheses underlying complex constructive activity.[32] This result differs from the ones reported by other researchers who claim high correlations, for example, in the case of the TOLB, when compared to other visuospatial subtests, such as those of the Wechsler Adult Intelligence Scale (WAIS).[27]

Concerning internal consistency for the items of the TDVB, TOLB and TRVB tests, an Omega coefficient of 0.79 was found; while for the praxis coefficients were 0.40 and 0.67, respectively; this indicates barely acceptable consistencies for both cases, and in practical terms allows us to suppose that this group of tasks, although they measure the same constructs, do not represent homogeneous tasks. It is worth mentioning that some researchers report a Cronbach's alpha of 0.66[43] for the TDVB; Strauss et al. indicate a Cronbach's alpha of 0.60 for TFCRO, 20 values considered relatively low.[44]

Due to the stated above, the Omega coefficient is shown, which, when working with factorial loads, allows to stabilize the calculations and reflect the true level of reliability.[45] These results theoretically agree with those reported by researchers, who consider that a subject's performance on visuospatial tasks depends on the perceptual task, even in the case of apparently related perceptual tasks, for example, subjects who perform well on discrimination tasks and orientation, do not necessarily perform well in movement discrimination.[46] These individual differences in visuospatial and praxical tasks were also reported in another study, in which the visual performance of the subjects showed substantial differences in two perceptual tasks (individuals who performed well in one task did not necessarily obtain good results in another).[47]

Regarding the pretest-posttest reliability, the present results -although they show concordances higher than 60% in most of the evaluated items-, indicate that when analyzing the pValue of the differences between the medians and the correlation coefficients, it is observed that in the assessment of praxis and gnosis, different values are found at both times of application of the tasks, and these are generally not correlated, which allows us to point out that statistically these measures are shown to be unstable over time.

This is consistent with studies that describe low test–retest reliability for visuoperceptual and constructive tasks, such as the one carried out with healthy subjects aged between 17 and 82 years, where the TRVB was applied. In this case, and after an interval of 21 days, the test-retest reliability was 0.57.[48] In another investigation that used a line orientation test and where healthy adults were re-evaluated after one year, a correlation coefficient of 0.59 was found.[49]

The importance of the normative data presented in this research derives from the delimitation of the sample: university students between 16 and 26 years old, with homogeneous sociodemographic characteristics (middle socioeconomic stratum), and at least 12 years old of schooling. The normative data provided differs from other studies in which measures have been standardized to assess praxis and gnosis tasks, especially due to the greater and broader age range used: 18 to 49 years [50] and 18 to 55 years.[51] It is important to point out that a precise age range will improve the reading of the subjects' praxic and gnosis performance characteristics. Some researchers have considered that determining small intervals in age in the standardization of psychometric tests would allow the professional to be aware in advance of a possible cognitive deterioration, in addition to establishing appropriate cut-off points according to age.[52]

Conclusions

Adequate reliability was found related to the application by different evaluators, with the exception of the TRVB, in which the medians show differences, probably attributed to the different forms of the test that can influence its application uniformity. A mean of 34.8 (SD=1.9) was found for the TFCRO, 126.7 (SD=63.5) for the measurement of time in the TFCRO and 28.7 (SD=3.4) for the TDVB. For the TRVB they are discriminated as follows: form "C" 7.9 (1.5), form "D" 7.7 (1.7) and form "E" 8.4 (1.5). In the case of the TOLB, there were differences between men and women: 48.5 (6.9) and 46.1 (8.3), respectively. These differences are consistent with research that found that men perform much better than women on tests of visuospatial skills, especially on the line orientation task.[52]

Adequate content validity was evidenced in all tests; as well as adequate criterion validity of praxis assessment measures, and, low criterion validity, internal consistency and test-retest reliability for the gnosis and praxis tests.

This result is consistent with research that has reported difficulties in the assessment of visuoperceptual and constructional skills, associated with the multifactorial nature of this type of tasks, which require visuospatial, executive and motor skills. Similarly, there are difficulties related to individual variations in the performance of a subject in same tasks according to time intervals, which adds to the wide variety of tests, forms and methods used to measure constructs such as visuo-constructional ability that further complicates the interpretation of the results.

Finally, considering that evaluation instruments have different forms of administration and qualification following diverse adaptations, it is important that neuropsychologists interested in university learning contexts, as well as in the assessment of young university population in clinical contexts, take into account the most appropriate form of administration and scoring for the context in which the test will be applied and, furthermore, consider to the most possible extent the use of standardized instruments in line with the specific culture background of the target population.

References

1. Luria AR. Lenguaje y pensamiento. Barcelona: Martínez Roca; 1986.
2. James–Prithishkumar I, Ludwig Edinger (1855-1918): Founder of modern neuroanatomy. Clin Anat. 2012; 25:155-7.
3. Luria AR. Fundamentos de neuropsicología. Barcelona; Fontanella; 1974.
4. Ardila A. Historia y clasificación de las agnosias. Rev Neuropsicol Neuropsi Neurocien. 2015; 15(1):1-7. https://revistannn.files.wordpress.com/2015/05/5-ardila_historia-agnosias-enero-junio-vol-151-2015.pdf
5. Schrager O, O´Donell C. Actos motores oro-faringo-faciales y praxias fonoarticulatorias. Fonoaudiológica. 2001; 47:22-32.
6. Belinchón M. Autonomía de la sintaxis y patología del lenguaje: datos y controversias. En Fernández-Lagunilla M, et al., editores, Sintaxis y cognición: introduccion al conocimineto, el procesamiento y los déficits sintáctios. Madrid: Sintaxix.1995; 409-36.
7. Ardila A, Rosselli M, Puente A. Neuropsychological evaluation of the Spanish Speaker. New York: Springer; 1994.
8. Rosselli-Cock M, Matute-Villaseñor E, Ardila-Ardila A, et al. Evaluación Neuropsicológica Infantil (ENI): una batería para la evaluación de niños entre 5 y 16 años. Estudio normativo colombiano. Rev Neurol. 2004; 38(8):720-31.
9. Beltrán-Dulcey C, Solis-Uribe G. Evaluación Neuropsicológica en Adolescentes: Normas para población de Bucaramanga. Revi Neuropsicol Neuropsiqui Neurocien. 2012;12(2):77-93.
10. Peña-Casanova J, Casals-Coll M, Quintana G, Sánchez–Benavides T, Rognonib L, Calvob R, et al. Estudios normativos españoles en población adulta joven (Proyecto NEURONORMA jóvenes): métodos y características de la muestra. Neurología. 2012; 27(5):253-60. https://doi.org/10.1016/j.nrl.2011.12.019
11. Arango-Lasprilla J, et al. Neuropsicología en Colombia: datos normativos, estado actual y retos a futuro. Colombia: Editorial Universidad Autónoma de Manizales; 2015.
12. República de Colombia. Departamento Administrativo Nacional de Estadística – DANE. Proyecciones de población a nivel municipal. Periodo 2018 – 2026. https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/proyecciones-de-poblacion
13. República de Colombia. Ministerio de Educación. Sistema Nacional de Información de la Educación Superior. Estudiantes matriculados en educación superior – Colombia 2020. https://snies.mineducacion.gov.co/portal/ESTADISTICAS/Bases-consolidadas/
14. Puerta IC, Dussán C, Montoya DM, Landínez D. Estandarización de pruebas neuropsicológicas para la evaluación de la atención en estudiantes universitarios. Rev. CES Psico. 2018; 12(1):17-31.
15. Puerta-Lopera I, Dussán-Lubert C, Montoya-Londoño D, Landinez-Martínez D. Datos normativos y estandarización de un protocolo de pruebas neuropsicológicas para la evaluación de la memoria en estudiantes universitarios. Psychologia. 2018; 12(2):23-35.
16. Puerta IC, Dussán C, Montoya DM, Landínez D. Estandarización de pruebas neuropsicológicas para la evaluación del lenguaje en estudiantes universitarios. Rev. Investigaciones Andina. 2018; 20(36):103-122.
17. Montoya DM, Dussán C, Pinilla VE, Puente A. Estandarización de la escala de autoconcepto AF5 en estudiantes universitarios colombianos. Rev. Ansiedad Estrés. 2019; 25:118-124.
18. Hernández-Sampieri R, Fernández-Collado C, Baptista-Lucio P. Metodología de la investigación. 5ª ed. México: MacGraw Hill; 2010.
19. Rey A. L'examen psychologique dans les cas d'en- cephalopathie traumatique. Arch Psychol (Geneve). 1941; 28:286-340.
20. Osterrieth P A. Le test de copie d'une figure complex: Contribution a l'étude de la perception et de la mémoire. Arch Psychol (Geneve). 1944; 30:286–356.
21. Corwin J, Bylsma FW. Psychological Examination of Traumatic Encephalopathy. Clin Neuropsychol. 1993; 7 (1):3–21. https://doi.org/10.1080/13854049308401883
22. Rey A. L'examen clinique en psychologie. Paris: Presse Universitaire de France; 1958.
23. Meyers JE, Meyers KR. Rey Complex Figure Test under four different administration procedures. Clin Neuropsychol. 1995; 9:63-7.
24. Meyers J, Meyers K. The Meyers scoring system for the Rey Complex Figure and the recognition trial: professional manual. Odessa, Fla.: Psychological Assessment Resources; 1995.
25. Waber DP, Holmes JM. Assessing children's memory productions of the Rey-Osterrieth Complex Figure. J. Clin. Exp. Neuropsychol.1986; 8:565-80.
26. Benton A. Benton Visual Retention Test. 5ª ed. San Antonio: The Psychological Corporation; 1992.
27. Strauss E, Sherman EMS, Spreen O. A compendium of neuropsychological tests: Administration, norms and commentary. New York: Oxford University Press; 2006.
28. Benton A, Hamsher K, Varney N, Spreen O. Review contributions to neuropsychological assessment: a clinical manual. PsycCRITIQUES. 1983; 28(10):806.
29. Peña-Casanova J, Gramunt N, Gich J. Test Neuropsicológicos. Fundamentos para una neurología clínica basada en evidencias. Barcelona: Masson; 2005.
30. Moses J. Factor structure of Benton's tests of visual retention, visual construction, and visual form discrimination. Arch Clin Neuropsychol. 1986; 1(2):147-56.
31. Ostrosky F, Gómez M, Matute E, Rosselli M, Ardila A, Pineda D. Neuropsi: atención y memoria. México: Manual Moderno; 2012.
32. Manga D, Ramos F. Batería Luria-DNA. Diagnóstico

neuropsicológico de adultos. Madrid: TEA; 2000.

33. Castillo-Ruben A, De Luna CJÁ, Castillo CR, Morales RJ. Rehabilitación neuropsicológica de la agnosia visual: presentación de dos casos. Rev Mex Neuroci. 2017;18(1):26-35.
34. Ramírez BY. Síndrome de Gerstmann del desarrollo. Rev Mex Neuroci. 2007; 7(6):622-627.
35. González MM, Armenteros HN, García BE, Casabona FE, Real GY. Aproximación terapéutica basada en la evidencia para contrarrestar apraxia total del habla en pacientes afásicos. Rev Mex Med Fis Rehab. 2007;19:56-62.
36. Cantero CD, González TR, García LY, Arrieta HT, García SS, Méndez MFM. Alteraciones neuropsicológicas, extrapiramidales y neuroimagenológicas en la demencia frontotemporal. Rev Cub Med Mil. 2013; 42(3):490-94.
37. Pinel J. Biopsicología. Madrid: Person education; 2007.
38. Rivas-Nieto J. Demencia frontotemporal: descripción clínica, neuropsicológica e imaginológica. Colomb. Med. 2014; 45(3):122-6.
39. Calvo-Merino B. Modelos teóricos y neuropsicología de las praxias. En Tirapu-Ustárroz J, Ríos-Lago M, Maestú-Unturbe F, ed. Manual de neuropsicología. Barcelona: Viguera; 2008. p eds., 125-47.
40. Gross R, Grossma, M. Update on apraxia. Curr Neurol Neurosci Rep. 2008;8(6):490-6.
41. Crook T, Larrabee G. Interrelationship among everyday memory tests: Stability of factor structure with age. Neuropsychology. 1988; 2:1-12.
42. Larrabee G, Crook T. Dimensions of everyday memory in age-associated memory impairment. Psychol. Assess. 1989;1:92–7.
43. Malina A, Regan T, Bowers D, Millis S. Psychometric analysis of the visual form discrimination test. Percep Mot Skills. 2001; 92(2):449-55.
44. Gregory R. Psychological Testing: history, principles, and applications. USA: Pearson College Division; 2013.
45. Ventura-León JL, Caycho-Rodríguez. El coeficiente Omega: un método alternativo para la estimación de la confiabilidad. Rev. Latinoam. Cienc. Soc. Niñez Juv. 2017; 15(1):625-27.
46. Halpern SD, Andrews TJ, Purves D. Interindividual variation in human visual performance. J.Cogn. Neurosci. 1999;11:521–34.
47. Song C, Kanai R, Fleming S, Weil R, Schwarzkopf S, Rees G. Relating inter-individual differences in metacognitive performance on different perceptual tasks. Conscious. Cogn. 2011; 20:1787-92.
48. Youngjohn JR, Larrabee GJ, Crook TH.. Test-retest re- liability of computerized, everyday memory measures and traditional memory tests. Clin. Neuropscyhol. 1992; 6:276–86.
49. Levin BE, Llabre MM, Weiner WJ, Sanchez-Ramos J, Singer C, Brown MC. Visuospatial impairment in Parkinson's disease. Neurology. 1991; 41:365–69.
50. Peña-Casanova J, Blesa R, Aguilar M, et al. Spanish Multicenter Normative Studies (NEURONORMA Project): Methods and Sample Characteristics. Arch Clin Neuropsychol. 2009; 24:307-19. DOI: 10.1093/arclin/acp027
51. Ganduli M, Snitz B, Ching-Wen L, et al. Age and education effects and norms on a cognitive test battery from a population-based cohort: The Monongahela – Youghiogheny Healthy Aging Team (MYHAT). Aging Ment. Health. 2010; 14(1):100-7. doi: 10.1080/13607860903071014
52. Ramos-Goyette S, McCoy J, Kennedy A, Sullivan M. Sex differences on the judgment of line orientation task: A function of landmark presence and hormonal status. Physiol. Behav. 2012; 105:1045–51. DOI: 10.1016/j.physbeh.2011.11.018

Article without conflict of interest