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THE UTILITY OF THE LURIA BATTERY FOR NEUROPSYCHOLOGICAL DIAGNOSIS OF ADULTS

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Actualmente existen diferentes herramientas basadas en el enfoque de evaluación neuropsicológica de Luria, pero los datos empíricos sobre las poblaciones españolas son limitados. El objetivo principal de este estudio es revisar evidencias científicas sobre las propiedades psicométricas del Luria Diagnóstico Neuropsicológico de Adultos (Luria DNA). Este estudio agregativo revisa sistemáticamente 14 investigaciones científicas (artículos y tesis doctorales) utilizando la "Luria DNA". De acuerdo con esta revisión, la batería "Luria DNA" permite detectar cambios neuropsicológicos en personas con diferentes tipos de patologías y discapacidad intelectual. Sin embargo, las evidencias normativas y clínicas son aún escasas. Se hacen necesarias futuras investigaciones para aclarar la sensibilidad y la especificidad de esta batería para discriminar entre personas mayores con deterioro cognitivo y personas cognitivamente sanas.
Palabras Clave: *Neuropsicología, Evaluación, Luria, Luria DNA, Revisión.*

Currently there are various tools based on Luria's neuropsychological assessment approach, but the empirical data on Spanish populations are limited. The main objective of this study is to review the scientific evidence on the psychometric properties of the Luria Spanish Battery for the Neuropsychological Diagnosis of Adults (Luria DNA). This aggregative study systematically reviews 14 scientific investigations (articles and doctoral dissertations) that use the Luria DNA. According to this review, the Luria DNA battery allows the detection of neuropsychological changes in people with different types of pathologies and intellectual disability. However, the normative evidence and clinical data are still scarce. Further investigations are needed in order to clarify the sensitivity and specificity of this battery in discriminating between older individuals with cognitive impairment and those that are cognitively healthy.
Key words: *Neuropsychology, Assessment, Luria, Luria DNA, Review.*

Neuropsychology studies the relationships between the brain and cognitive activity in healthy people and those with some type of brain damage (Ardila & Rosselli, 2007). One of the main objectives of neuropsychology is to evaluate strengths and weaknesses related to the cognitive profile (Manga & Ramos, 1999; Herreras, 2008), which can be carried out based on different paradigms of study. On the one hand, the behavioral paradigm –which is more qualitative– is interested in *how* the individuals being evaluated solve the different tasks that are presented to them. On the other hand, the psychometric paradigm seeks a standardized evaluation, which contributes some methodological advantages. However, it sometimes lacks a definite theoretical support (Sergui, 2003).

The approach of Alexander Romanovich Luria (1902-1977) made it possible to develop the clinical research method based on the case study. This author worked with Vygotsky (1886-1934) and together they moved towards a reformulation of the concepts of "localization" and "function", giving way to a new perspective on the relationship between the brain and behavior (Peña-Casanova & Pàmies, 1985). Luria is one of the fathers of modern neuropsychology and his theory of the three functional blocks or systems of the brain has been one of the most important pillars of this discipline (Tupper, 1999a). He combined the influence of different paradigms and his major contributions to neuropsychology were the following (see Cole, 2005): a) the theoretical proposal of the three functional cortical blocks and their organization in brain systems; b) functional systems include the cultural organization of the environment as one of their key constituents; c) the need for an evaluation method that combines theory and practice. Luria argues that superior brain functioning exists thanks to the interaction of differentiated brain structures, each of which makes a specific contribution to the dynamic whole and participates in the functioning of the system fulfilling its own functions. This approach differs from localization models, from classical neurology, and from the psychometric approach (Bilder, 2011).

According to Luria (1980), three functional systems can be distinguished. There is there activation block, whose representative structure is the reticular formation, which is

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responsible for regulating the state of activation in the brain (i.e., alert level, cortex tone and waking state). Then there is the functional block of the "inputs", located at the cortical level in the parietal, temporal and occipital lobes, responsible for the reception, processing and storage of sensory information. This block is organized according to the law of hierarchical structure and decreasing specificity: with a structure of primary (reception of information), secondary (codification) and tertiary areas (outputs), the latter being no longer specific to a sensorial modality (they are supramodal). Finally, there is the functional block of behavioral programming, intentionality and control of activity (e.g., attention and concentration), which is associated with the activity of the most anterior cortical areas of the brain, above the fissure of Rolando. The system is self-regulating, once the brain has performed an action, it judges the results in relation to the basic plan, and terminates the action when it has satisfactorily completed the program (Luria, 1980).

This perspective allows us to predict that the probability of cognitive damage is a consequence of an injury in a specific area corresponding to a particular functional block. In this way, an injury to the areas of the brain stem or the reticular system (first block) would most likely cause a deterioration in the waking state, a loss of selectivity or discrimination of stimuli. With respect to the second block, an injury in the primary areas will imply a sensorial deterioration of a specific modality. In the secondary areas, an injury will probably cause a loss of the analysis capacity and deterioration in coding, as well as a behavioral disorganization when the damage is in the tertiary area of this second block. . Finally, an injury to the third functional block will most likely converge to an alteration of intentional behavior, a loss of initiative, and an inability to express one's thoughts (Ardila & Ostrosky-Solis 1991, Manga & Ramos 2000, Xomskaya, 2002).

This theory of functional units is an educational resource that explains brain functioning (Tupper, 1999a), and has great empirical support based on neuroimaging techniques (Ardila & Bernal, 2007; Cagigas & Bilder, 2009; Palchaska & Kaczmarck, 2012), with which its usefulness in studying the phases of sleep has been tested (Arnoldo & Sánchez, 2016). Luria's theory has been the basis of later cognitive theories on parallel processing and neural networks (Tupper, 1999b), the third functional block being the embryo of the concept of executive functions (Ardila, 2008). His original approaches have progressed to what is known as neuro-lurianism (Ardila, 1995), on which the Barcelona Test (Peña-Cassanova, 1991) was constructed, and they have been reformulated in neuropsychological (Planning-Attention-Simultaneous-Successive) theories on intelligence (Das, 1999). Finally, note that the theory of the three functional blocks of Luria has been updated by Mesulam (2000), who advocates the organization of functional systems at different levels of the Central Nervous System. Thus, cognitive functions depend on neural networks and each brain region is integrated into different neural networks that support cognitive processes. In many cases, injuries in different places will cause the same cognitive deficit whereas injuries at a single point, where several neural networks converge, can cause a disorder in different cognitive functions.

Neuropsychological Batteries in Spanish

The neuropsychological perspective of Luria is based on syndromic analysis with an eminently clinical approach (Tupper, 1999b; Cole, 2005). The characteristics of Luria's neuropsychological assessment could be summarized in the orientation to the cognitive process underlying the task, the qualitative approach to the case, a patient-centered administration, and neuropsychological hypothesis testing (Bornschlegl & Petermann, 2013). Thus, the neuropsychological assessment is conceived as a patient-adapted (i.e, non-standardized) study so the specific test per se is not as important as the mode of administration in finding out which cognitive processes are affected (Deegener, Dietel, Kassel, Matthai, & Nödl, 1992).

The influence of Luria's theory and his evaluation method is very broad. The first test developed based on Luria's theory was the "Luria-Christensen" battery (1975), which systematized the tests that Luria used in his assessments. On the other hand, Golden, Purisch, & Hammeke (1979) developed the Luria-Nebraska Neuropsychological Battery, translated and adapted for Spain and Latin America (Ardila, 1999), with 269 items distributed in 11 scales (duration: two and three hours), for individuals from the age of fifteen (Golden, Purisch, & Hammeke, 1979). However, this battery has not achieved a correct adaptation of the original qualitative method proposed, since priority is given to the number of tests performed and not to the correct analysis of errors. Other relevant tests based on Luria's method are: the Luria Neuropsychological Diagnosis of Adults (Luria DNA, Manga & Ramos, 2000), Kaplan Baycrest Neurocognitive Assessment (KBNA, Leach, 2000) and Kaufman Short Neuropsychological Assessment Procedure (K-SNAP, Kaufman, 1994).

Luria DNA is the only Spanish-language battery for adults with validation in Spanish, since the Luria Neuropsychological Diagnostic - Infants (Luria DNI, Manga & Ramos, 1991) and Luria - Initial (Manga & Ramos, 2006) batteries are focused on the child population. The KBNA (Leach, 2000) is a battery, designed for ages 20 to 89, whose tests combine behavioral neurology and the neuropsychological approach. The broad areas of evaluation that it contemplates are attention-concentration, immediate and delayed memory, spatial processing, verbal fluency, and reasoning. In the case of K-SNAP (Kaufman, 1994), it is a battery of three levels of complexity for the evaluation of individuals aged between 11 and 85 years and used as a rapid cognitive evaluation or as part of a more complex process of neuropsychological assessment.

The Luria DNA battery is a battery that combines the qualitative and quantitative perspective (composed of 8 subtests per area explored) and the attention test (Manga & Ramos,

2000; Osmon, 1989). It was developed based on the material by Christensen (1978). The maximum score on the battery is 229 points. It has a duration of about fifty minutes and is intended for the diagnosis of adults. The areas it explores are the following: 1) visuospatial area: it evaluates superior visual functions; 2) area of language: it tests the production and comprehension of speech; 3) area of memory: this is composed of a set of tests linked to perception and complex intellectual forms; 4) area of intellectual processes: it evaluates constructive activity and general intellectual deterioration; 5) Attention test: this consists of a set of items on alertness, selective attention, distractibility, focused attention and interference.

The battery considers a series of *vacillations* to systematize the qualitative observations while an item is solved. This concept refers to the realization of the item correctly but in special conditions, which are categorized into three types and must be specified as follows: A) Imprecision vacillation: any doubts, hesitations, inaccuracies or corrections valid within the allotted time; B) Attention vacillation: in some items in which it is not specified otherwise, the instructions can be repeated if a lack of attention has been observed in the subject or if he/she requests it; C) Time vacillation: unless otherwise stated in the item, no more than 10 seconds is granted for a response. An answer that is out of time scores as correct if it is, but this type of vacillation is noted.

The main objective of this study is to review the scientific evidence on the psychometric properties of the Luria Neuropsychological Diagnosis of Adults (Luria DNA) in the adult Spanish population.

METHOD

Materials

This study aims to collect aggregate information on the use of the Luria DNA Battery in the Spanish population. We have reviewed a total of 14 studies where the Luria DNA Battery was used for neuropsychological evaluation. Of these, three were normative studies in the healthy population, four were case studies, three were doctoral theses, two were studies of case-control group, one was on the clinical population and one was on intervention with pre-post design. All are summarized in Table 1.

Procedure

Different searches were performed on the PsycInfo, PubMed and Google Scholar databases using the terms "Luria DNA" and "Evaluación Neuropsicológica" (or Neuropsychological Assessment). Google Scholar was the only database with bibliography available. In total, 260 results were found and, of these, 31 were studies carried out in the adult population.

Of the 31 studies, only 17 turned out to be studies in which the Luria DNA Battery was used. In addition, a doctoral thesis from the Teseo database was included which did not appear in the search, and only works with a control group that included healthy participants were considered. We excluded studies that were merely descriptive, without similar groups, oriented to the study of psychosocial problems (e.g., abuse, Torres García, 2014) or peripheral pathologies (Jurado-Gámez, Guglielmi, Gude, & Buela-Casal, 2016). All of the studies found are listed in Table 1.

Analysis of the information

The information was structured in the following blocks: normative studies in healthy population, people who have suffered brain damage (acquired functional deficit), psychiatric disorders, neurodevelopmental disorders (people born with a functional deficit) and studies on the effectiveness of rehabilitation plans for people with Parkinson's and with intellectual disability.

RESULTS

Validity studies in healthy people

The battery has normative data validated in Spain for different educational levels (high school, students currently at university and those who have already graduated) and examples of cases of neuropsychological clinical analysis. It also has test-retest reliability (.83) and concurrent validity with the Wechsler adult intelligence scale (see Manga & Ramos, 2000).

Bausela-Herreras (2007a) and Herreras (2007ab) conducted a study on university students (N = 115, 83.5% female) which found: a) the factorial structure of the Luria DNA battery consists of five factors with an explained variance of 79.33 %; b) the Luria DNA battery has an adequate convergent validity with the abridged Wechsler intelligence scale (Bausela-Herreras, 2007b and Herreras, 2010a), finding moderate correlation indices between the Luria DNA and the WAIS III subtest areas (r = .69), the areas of Luria DNA and the scales (r = .57), as well as the WAIS III factors (r = .652). The correlation between the memory area (Luria-DNA) and the working memory factor (WAIS-III) was r = .441, while the visuospatial area (Luria-DNA) correlated with the perceptual organization factor (WAIS-III) of r = .41. In the area of language, a significant correlation was also found of the verbal comprehension factor (WAIS-III) and the receptive speech (r = .177, p = .059) and expressive speech subtests (r = .182, p = .05) of the Luria-DNA. These correlations are congruent with the results obtained by Manga and Ramos (2000) when they validated the test.

Studies in people with brain damage

A study that analyzed the neuropsychological deficit of 15 patients with brain damage (stroke, tumor, traumatic brain injury and schizophrenia) of different etiologies (Bausela-Herreras, 2009a; Herreras, 2010b), revealed a decrease in the learning curve (trials) in the memory test of the Luria DNA battery. Using the same sample, it is described in another study that these patients present a greater deterioration in the areas of memory and attentional control compared to language. Also, a lower score was observed of the sample with respect to the total score in the expressive speech subtest and in logical memorization, as well as a high number of attentional and imprecision vacillations. However, the results are merely

TABLE 1
SUMMARY OF THE STUDIES REVIEWED

	Study	Objective	Sample	Socio-demographics	Control Group	Results
Normative studies	Bausela-Herreras (2007), Herreras (2010)	Factorial study, concurrent validity	115 university students	74.8% between 19-24 years, 17.4% between 25-30 years the rest between 31 and 48 years.	No	5 factors (79.3% variance explained)and adequate concurrent validity with WAIS
Studies in people with neurological disease	Bausela-Herreras (2009) and Herreras (2010)	Study of the neuropsychological deficit and learning curve	15 patients with frontal brain damage with different etiopathogenesis: cranioencephalic trauma, cerebrovascular accident and neuropsychiatric condition (schizophrenia).	Unknown	No	Attenuation of the learning curveHigher score in language, lower score in memory and attentional control. Greater presence of vacillations of attention and precision.
	Bausela-Herreras (2009)	Case study on the cognitive profile of two people with brain damage	A 35 year old man and a 70 year old man	52.5 years	No	35-year-old male was affected in the areas of attention, memory and conceptual activity and 70-year-old man logical memory
	Zamora & Rivera (2012)	Case study	Brain damage of diverse etiology and location	29.3 years (6 men and 2 women)	No	Concordance results of Luria DNA and damaged brain areas
	Estrada (2014)	Cognitive profile	7 patients with multiple sclerosis, divided into two groups: four patients with major brain damage and three patients with minor affectation	37 years (2 men and 5 women)	No	Significant alterations in visual perception with respect to normality.
Psychiatric patients	García-Pérez et al. (2011, 2012)	Neuropsychological performance	149 participants in combined treatment with antipsychotics	38.5 years (38.7% women) with high school education (42%)	No	Scores lower than the average of people without mental impairment in the attentional control subtest.Late onset is associated with worse visual perception scores. Early-onset patients score lower on thematic drawings (intellectual processes)
	Herreras (2007)	Case study	Personality disorder	19 years (one man) with compulsory secondary education	No	Neuroticism and psychoticism is associated with difficulties of inhibition and working memory.
	Antoraz, Vicente, Moreo y Recio (2004)	Cognitive performance	30 participants:6 with Asperger's syndrome, 18 withSchizophrenia and 6 withBipolar Affective Disorder.	Asperger's Syndrome: 25.5 years (*SD* = 4.9) (1 with higher education)Schizophrenia: 29.5 years (*SD* = 5.3) (4 with higher education)Bipolar Affective Disorder: 29.16 years (*SD* = 6.1) (none with higher education)	No	No significant differences were found among the three groups on the Battery either in the total score or the subtest.
Addictions	Belda (2015)	Cognitive performance	144 participants who demanded treatment for addiction (alcohol, stimulants, polyconsumers) control group.	Group of patients:37.93 years (*SD* = 11.3) (28.93% women, 45.6% with primary studies)Control group: 38.39 years (*SD* = 12.4) (33.3% women, 41.7 with secondary studies)	Yes, matched in sex and age. Differentiated in work situation: greater percentage of students in the control group (33.3%).	Alcohol users scored statistically less on visual perception, thematic drawings, and attentional control. Time vacillations were significantly higher in the alcohol group than in the other two.
Developmental Disorders	García-Alba (1996), García- Alba, Portellano & Díaz-Otero (2010)	Cognitive performance	179 participants (43 with Down syndrome vs. 136 control)	-	Yes. There are no data on sociodemographic variables.	Significantly lower scores were observed in the Down syndrome group with respect to control in all areas ($p < .05$).
	García- Alba, Portellano & Martín-Palacio (2011) and García- Alba, Portellano-Pérez & García-Pérez (2011)		105 participants,22 participants with Down syndrome in adulthood (59% women) vs. 30 controls (60% women)	Adults with Down syndrome: 19.7 years (*SD* = 1.3) (59% female)Adult control group: 19.2 years (*SD* = 1.3) (60% female)	Yes, equal in sex and age.	Significantly lower scores in Down syndrome than in controls. Areas most affected: Visual perception, spatial orientation, receptive speech and expressive speech, immediate memory, thematic drawings and texts and conceptual activity.
Rehabilitation studies	Sánchez-Menárguez (2015)	Efficacy of a music therapy program	Parkinson's Disease	54.83 years (4 men and 2 women)	No	Luria DNA scores improve after treatment except in the visuospatial area.
	Gómez-Jarabo, et al., (2008)	Efficacy labor integration program	117 participants with intellectual disability (mild mental retardation, 70.6%).	28.47 years (*SD* = 5.7) (35.3% female)	No	Significant improvements in spatial orientation scores (visuospatial area), thematic drawings and text, and conceptual and discursive activity (area of intellectual processes).

Standard Deviation (SD), Luria Neuropsychological Diagnosis Battery for Adults (Luria DNA)

descriptive and the study sample is very heterogeneous, which does not allow us to determine its diagnostic capacity in a given population and the study does not reveal the discriminative capacity of the test (sensitivity or specificity).

In a case study of patients with cerebrovascular accidents (a 35-year-old right-handed man with left-hemisphere damage and a 70-year-old man with subcortical areas affected by stroke, Bausela-Herreras (2009b) found that in the first case the areas of attention, memory and conceptual activity were affected and in the second the logical memory was affected with a centile less than two. Thus, a concordance with the functional blocks of Luria between the neuropsychological profiles and the affected areas was observed in a sample of 8 patients (six men and two women) with traumatic brain injury (TBI) of heterogeneous location (Glasgow scale less than 8), where patients with psychiatric affectation, congenital disease, drug dependence or mental retardation were excluded (Zamora & Rivera, 2012).

Finally, the Luria DNA was used for the analysis of neuropsychological deterioration in patients with multiple sclerosis (Estrada, 2014). In particular, 16 patients with secondary progressive form, 49 patients with recurrent form and 15 control participants were considered. The results indicated significant alterations in visual perception with respect to normality. With respect to the learning curve, it is worth mentioning an advantage in remembering words from the second test in recurrent forms with respect to the progressive secondary ones. By means of a cluster analysis, two groups with different levels of cognitive deterioration (less severe and more severe) were formed, from 7 patients with MS, the first with four patients with major brain damage (a 27-year-old man with progressive secondary sclerosis with paraparesis, a 37 year old woman with relapsing-remitting (RR) multiple sclerosis, a 46-year-old man with RR multiple sclerosis, and a 39-year-old woman with RR multiple sclerosis), and a second group of three patients (a 36 year old woman with progressive secondary sclerosis, a 41 year old woman with RR multiple sclerosis and a 33 year old woman with progressive secondary sclerosis).

Psychiatric patients

In a study with 150 participants with schizophrenia according to DSM-IV criteria (García-Pérez, 2011; García-Pérez, 2012), most of them paranoid (65.3%), the mean scores on the different areas of the Luria DNA battery were compared according to the age of onset of the disorder. The results revealed that patients scored lower (M = 19.18) than the mean of individuals without schizophrenia in the attention control subtest of the Luria DNA. In addition to this, the tests that were most difficult for patients were studied using differences in standard deviations, with the immediate memory subtest as the most complex, followed by the sub-tests of logical memorization and receptive speech. On the other hand, the visual perception test was the least difficult for the sample. The same study also describes how the late onset of the disease has negative repercussions on visual perception, with scores in this area being significantly lower in the group of people with late-onset schizophrenia than in the early-onset group (F = 6.414; p <.002). However, early-onset patients scored significantly lower (F = 4.618, p <.011) in the task of thematic drawings (area of intellectual processes) (group less than 20 years M = 57.39, SD = 13.69) in comparison with the scores of the other groups in the same area (group of 21 to 24 years old M = 62.59, SD = 8.44, group of older than 25 years: M = 63.04, SD = 7.26).

On the other hand, in the case study of a 19-year-old boy (Herreras, 2007c), a link between neuroticism and psychoticism was found with attention capacities and executive functions (inhibition and working memory). However, the results of this study are those derived from the single case study and it is not possible to generalize its conclusions. Finally, some studies, with larger samples, carried out on people with schizophrenia and Asperger's syndrome find that the performance in tasks related to theory of mind is related to difficulties in the conceptual activity and subtest of drawings and text, which studies the understanding of messages in different formats and requires a special analytic-synthetic effort to reach the solution (Antoraz, Vicente, Moreo & Recio, 2004).

Neurodevelopmental Disorders

There are several studies in which it is concluded that the Luria DNA battery is sensitive to the neuropsychological deficits of Down syndrome (García-Alba, Portellano & Díaz-Otero, 2010; García-Alba, Portellano & Martín-Palacio, 2013; García-Alba, Portellano-Pérez & García-Pérez, 2011). García-Alba (1996) and García-Alba, Portellano and Díaz-Otero (2010) observed that spatial orientation, immediate memory and attentional control were the areas most affected in this group with respect to controls, however, the age range of the participants is not specified, which prevents us from knowing the equivalence of the groups. Recently, García-Alba et al. (2011) carried out a study with a sample of 22 participants with Down syndrome (59% female) and 30 control participants (60% female) in adulthood (17-21 years). The study concludes that the scores on the Luria DNA were significantly lower, compared to the control group, in all areas. Furthermore, the study found no significant differences between women and men with Down syndrome in any area.

Finally, the study by Antoraz, Vicente, Moreo, and Recio (2004) on 6 patients with Asperger's syndrome (6 men), 18 patients with schizophrenia (10 men) and 6 patients with bipolar affective disorder (3 men) found no significant differences among the three groups in either the total score or the subtests of the battery. However, there were lower scalar scores in patients with Asperger's in the total score, expressive speech, logical memory, in drawings and texts and conceptual activity with respect to patients with schizophrenia. In turn, the scores of patients with schizophrenia were lower compared to bipolar patients. In addition, it should be noted that the groups were not fully matched in age, the generalized developmental disorder group had a mean age of five years less than the mean age of the other two groups, and the socioeconomic level also differed in the group of generalized developmental disorder where no participant had a high level.

Addictions

The main objective of the studies presented here is to analyze how drug use affects neuropsychological performance on the Luria DNA.

In a study by Sanz (1997), with the participation of 15 active polydrug users (12 males), 34 abstinent polydrug users (28 males) and 24 controls (20 males), who had not previously used drugs, it is concluded that there are alterations in specific cognitive domains of the battery and a preservation of the general intellectual capacity. These participants were between 18 and 35 years of age and came from different social institutions involved with this group. By areas, the active polydrug users scored less than the control group in the visuospatial area (t = 2.22, p <.05), that of language (t = 2.21, p < .05) and in that of intellectual processes (t 2.60, p <.05). In addition, the total score on the battery with respect to the control group was also lower for polydrug users (t = 2.65, p < .05). With respect to the group of abstinent polydrug users, lower scores were also observed than in the control group in visual perception (t = 2.71, p <.01), immediate memory (t = 2.32, p <.05) and logical memorization (t = 2.14, p <.05), as well as the total Luria DNA battery (t = 2.44, p <.05). In general, the group of abstinent polydrug users scored less than the control group in areas of memory (t = 2.15, p <.05), however, not in other areas such as visuospatial or language.

In a more recent study, Belda (2015) analyzed 144 participants (34% women) who demanded treatment in an Addictive Behavior Unit and 36 in a control group (33.3% women). The control group consumed drugs an average of once a week and were not receiving any pharmacological treatment. The groups were matched in sex, age and civil status according to statistical analysis, however, differences were found in the work situation and educational level: the group of drug users had a lower level of education and higher unemployment. In the study, the alcohol users scored poorly on visual perception, visual processing, immediate memory, logical memorization, thematic drawings, conceptual activity, and attention tests, while maintaining a score within the normal range for oral language. On the other hand, polyconsumers scored less in logical memory than the control group, while maintaining unaltered visual perception, spatial orientation, thematic drawings and conceptual activity, as well as the attention and expressive speech subtests. After comparing the groups, it was found that alcohol consumers scored significantly less in visual perception (M = 23.48, F = 4.313, p = .015), in thematic drawings (M = 27.32, F = 3.186, p = .044) and attentional control (M = 27.19, F = 4.276, p = .016). Also, the time vacillations were significantly higher in the alcohol group than in poly drug users and the control (M = 2.68, F = 5.180, p = .007). It was concluded that the Luria DNA battery is sensitive to the neuropsychological damage associated with the consumption of alcohol and other substances.

Rehabilitation studies

The Luria DNA battery has also been used as an instrument to measure the effectiveness of rehabilitation treatments. In a case study of elderly people with Parkinson's, analyzing the effectiveness of a music therapy program (Sánchez-Menárguez, 2015), it was found that Luria DNA scores improved after intervention in six patients with Parkinson's disease. In all patients, the area of memory (immediate and logical memory) and the visuospatial area were the most impaired. However, the area of language and speech (expressive or narrative) were the least deteriorated areas in the sample. After the sessions with music therapy, although the scores improved in the memory area, they were still below normal, whereas in the visuospatial area there was no improvement. On the other hand, in the case of the intellectual and language areas, the scores were within the range of mean scores and the remaining scores improved slowly during the intervention. Finally, the number of vacillations of attention and imprecision decreased throughout the study.

The same battery has been used for the neuropsychological evaluation of people with intellectual disabilities (N = 117) after applying a labor integration program (Gómez-Jarabo, et al., 2008). A significant improvement was found of the scores after the program in spatial orientation (p = .001), thematic drawings and text (p = .003) and conceptual and discursive activity (p = .008).

DISCUSSION

The Luria DNA battery is a neuropsychological battery with empirical support for the neuropsychological evaluation of adults. There are many published studies that support the presence of cognitive deficits in different neurological, psychiatric and other medical and social conditions, such as TBI (Zamora & Rivera, 2012), people with schizophrenia (García-Pérez, 2012), multiple sclerosis (Estrada, 2014) or intellectual disability (Gómez-Jarabo, et al., 2008). The battery has good psychometric properties related to test-retest reliability and convergent validity with the Wechsler intelligence scale (WAIS-III). Nevertheless, psychometric properties such as the level of internal consistency of the test, sensitivity and specificity in the different disorders studied should be further investigated. Furthermore, there are no cut-off points to establish the presence of neuropsychological alterations in people with different sociocultural backgrounds. Currently, the only normative scale that exists has been carried out with university students. Therefore, normative studies are required in adults with different sociodemographic characteristics (age, sex and educational level). Moreover, the battery's validity for evaluating intervention outcomes is almost unknown and must be confirmed in randomized controlled clinical trials.

In relation to the other neuropsychological batteries, the Luria DNA finds correlations congruent with the results of the different subtests and WAIS III tests, so the information provided by the two tests is perfectly compatible and can be seen as complementary, since the main difference between the two tests is that the Luria DNA is based on a theoretical foundation on the cerebral organization that has been empirically contrasted (Ardila & Bernal, 2007; Cagigas & Bilder, 2009; Palchaska &

Kaczmarck, 2012), which helps the neuropsychologist to locate possible brain damage without waiting for neuroimaging tests. On the other hand, with respect to the other batteries based on Luria's theory, the Luria DNA is more exhaustive and more faithful to Luria's original evaluation method than other batteries, such as the Luria-Nebraska. Furthermore, the evaluation that it contributes should be used to later select the most effective neuropsychological rehabilitation strategies (i.e., cognitive stimulation and cognitive training).

This study has some limitations. Firstly, the reviewed articles all belong to *Google Scholar* since no work with the same references was found in other databases. This may be because the bases consulted are of Anglo-Saxon origin and the Luria DNA has been developed and standardized in Spanish, so its usefulness in English-speaking countries has not been considered.

Finally, the possible use of the Luria DNA in older people requires a review of the tasks to reduce its complexity and application time. In summary, the clinical studies performed essentially cover isolated cases or heterogeneous groups of patients, which do not establish diagnostic values of the test (e.g., sensitivity or specificity) or reference values for a normative group (Bausela-Herreras, 2009b; Zamora & Rivera, 2012; Herreras, 2007c).

CONFLICT OF INTERESTS

There is no conflict of interest

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