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Neuropsychological differences between samples of dyslexic and reader children by means of NEPSY

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Dyslexia and other reading disorder concepts are used to describe the difficulties of children who cannot read, despite their cognitive capacity and after having spent a long period of learning and practicing. This paper evaluates the neuropsychological performance in NEPSY subtests and the differences between dyslexic and reader children. The evaluation involved a sample of 30 children: 1) control group of 10 reader children; 2) group of 10 children with low probability of being diagnosed as dyslexic; and 3) group of 10 children with probable and very probable dyslexia, according to the criteria of Bongo Test. Comparing group 1 to 3, the 20 subjects are correctly classified in the expected group by discriminant analysis, but the Stepwise Wilks' lambda method only selects 6 of the NEPSY subtests: Oromotor Sequences (better performance of the of readers children) and Fingertip Tapping, Visuomotor Precision, Finger Discrimination (non preferred hand) Arrows, and Route Finding (better performance of dyslexic children). Despite all, the Mann-Whitney rank-sum U tests point significant differences between groups in Tower, Knok and Tap, and Manual Motor Sequences (better performance of reader children), and Finger Discrimination-non preferred hand (better performance of dyslexic children). Finally, multiple regression analysis carried out with the NEPSY subtests as predictor variables and each one of the reading Bongo test as dependent variables, with the sample of two groups of dyslexic children (n =20), select different NEPSY variables for each dependent Bongo Literacy Test: Spelling mistakes, writing errors, reading time, reading errors, and reading comprehension.

Keywords: *neuropsychology, dyslexia, childhood disorders, NEPSY.*

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Diferencias neuropsicológicas entre muestras de niños lectores y disléxicos mediante el NEPSY

La dislexia y otros conceptos relacionados con los trastornos de lectura son utilizados para describir las dificultades de los niños que no pueden leer, a pesar de su capacidad cognitiva y después de haber pasado un largo periodo de tiempo de aprendizaje y práctica. Este artículo evalúa el rendimiento neuropsicológico en los subtest del NEPSY y las diferencias entre los niños disléxicos y los lectores. La evaluación implica una muestra de 30 niños: 1) grupo de control formado por 10 niños lectores; 2) grupo de 10 niños con baja probabilidad de ser diagnosticados como disléxicos; y 3) grupo de 10 niños con probable y muy probable diagnóstico de dislexia, según los criterios del Test Bongo. Comparados el grupo 1 con el 3, los 20 sujetos son correctamente clasificados en el grupo esperado mediante un análisis discriminante, pero el método de pasos Wilks' lambda solamente selecciona 6 subtests del NEPSY: Secuencias Oromotrices (mejor rendimiento de los niños lectores), y Golpeteo con los Dedos, Precisión Visomotriz, Discriminación de Dedos (mano no preferentes), Flechas, y Encontrar la Ruta (mejor rendimiento de los niños disléxicos). A pesar de todo, el test de Mann-Whitney señala diferencias significativas entre dichos grupos en Torres, Nudillos y Palmadas, y en Secuencias Motrices Manuales (mejor rendimiento de los niños lectores), y Discriminación de Dedos de la mano no preferente (mejor rendimiento de los niños disléxicos). Finalmente, con la muestra de los dos grupos de niños disléxicos (n =20), los análisis de regresión múltiple llevados a cabo con los subtest del NEPSY como predictores y cada una de las variables del Test Bongo como dependientes seleccionan diferentes variables del NEPSY para cada una de las dependientes de dicho test de lecto-escritura: faltas de ortografía, errores de escritura, tiempo lector, errores de lectura, y comprensión lectora.

Palabras clave: *neuropsicología, dislexia, trastornos infantiles, NEPSY*

Introduction

Reading disorder, specific reading disorder, dyslexia, developmental dyslexia, reading disabilities, specific reading disabilities and so forth are concepts used to describe the difficulties of children who cannot read or the ability is substantially below the expected potential, despite their cognitive capacity and after having spent a long period of learning and practicing. Its prevalence among children varies from 4% to 10%, according to the different etiologic and diagnostic criteria and etiologic models employed. The DSM-IV-TR (APA, 2000) says that reading disorders occur on their own or accompanied by math or writing disorders in approximately 4% to 5% of all learning disorders and that 60% to 80% of those diagnosed with the disorder are male, which may be explained by a possible bias in clinical procedures toward identifying boys, since they display the disturbed behaviours associated with learning disorders more frequently than girls do. However, the manual goes on to say that the disorder appears in similar rates in both genders when a careful diagnosis and strict approaches are used.

Yet, the disorder has been reported in all countries, and for all languages, in which studies have been conducted. Goulandris (2003) compiles contemporary studies on this subject in different languages, both those that are culturally closest to English, such as German, French, Spanish, Greek, Norwegian, Polish and Hebrew –which present varying degrees of grapheme-phoneme correspondence- and those that are more distant as African languages, the logographic languages of China and Japan and, even, a chapter discussing the problems of blind children learning Braille–.

Among the causal factors of reading difficulty that the various researchers have identified, we find a deficit in phonological awareness and language acquisition (Goswami, 2002), deficiencies in cognitive capacity (Werker & Tees, 1987), problems of auditory perception (Nix & Shapiro, 1986) and/or the perception of rapid stimuli (Tallal, 1999), problems of visual perception (Lovegrove, Garzia & Nicholson, 1990; Williams & Lecluyse, 1990) and/or the malformation of the eye and retina (Grosser & Spafford, 1989), problems in the secondary stages of reading (Katz & Sevush, 1989), attention deficit (Dickstein & Tallal, 1987; Felton & Wood, 1989), anatomical brain differences (Kaufman & Galaburda, 1989) and/or minor cerebral dysfunction (Kayser, 1989), genetic problems (DeFries & Alarcón, 1996), etc.

Today a number of researchers question the long-held belief that dyslexia is a discrete diagnostic entity. In this line, Shaywitz, Escobar, Shaywitz, Fletcher and Makuch (1992) carried out a longitu-dinal study with 414 children after the age of kindergarten. Their results suggest that dyslexia occurs on an unbroken continuum (Lyon, Shaywitz & Shaywitz, 2003; Shaywitz *et al*., 2004), which mixes imperceptibly with normal reading ability so that a cut-off point between dyslexics and subjects with a normal ability cannot be identified.

There are multiple models of diagnostic criterion for dyslexia. But, in general, all authors coincide in pointing out a denominated exclusion criterion of other disorders in the first place and afterwards they add other according to the etiologic bases. Ackerman and Dykman (1995), for example, propose the exclusion criteria and the bad performance in reading:

– Verbal IQ, Performance IQ and full-scale IQ WISC-R bigger or equal to 80. Normal vision and audition; normal physical and neurological state. Previous regular attendance and school instruction. Not to need of psychiatric intervention.

– Score below 80 in reading test WART-R.

The DSM-IV-TR diagnostic criteria for reading disorder in 315.00 (APA, 2000), and the World Health Organization (2006) classifies specific reading disorder in ICD-10 as F81.0. The ICD-10 includes *backward reading* developmental dyslexia and specific reading retardation and excludes acquired alexia and dyslexia and reading difficulties stemming from emotional disorders.

Lyon, Shaywitz and Shaywitz (2003) used the following definition: «Dyslexia is a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and / or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge».

The Bongo Test has 4 criteria (Aguilar, 2004): The first correspond to the exclusion criterion of other authors, the second emphasizes the difficulties of reading and writing, and third and fourth include behaviours related to personality and motivation of the affected children; these are:

1. The child has suffered continuous failure in the learning literacy process without any serious cause having been identified as a justification (exclusion criteria).
2. Impossibility or severe deterioration in reading that can affect to the writing.
3. Failure affects the person and their motivation for reading and writing.
4. Compensatory strategies appear.

The criterion 3 deals with the effect of failure on the person and their motivation, and the 4 with the learned behaviour in reading and writing situations, and with coping strategies. We add these two criteria because their knowledge is extremely important before starting treatment.

The dyslexic behaviour is affected by some personality traits and motives. Aguilar and Aguilar (2004) present a study of different personality and motivations variables that have significant effect on some cognitive, reading and writing tasks. Specifically, we think that some traits can be impacting and reinforcing the dyslexic behaviour. Concretely, some personality traits have relations with some characteristic errors on literacy and with the attitude and coping in front of the reading and writing problems of the different children. Therefore, a continuous failure in the learning of reading and writing tasks can establish different habits associated to different traits of personality and creating a feedback process of the dyslexic behaviour. It should be kept in mind the important function of specific personality traits to design the treatment program for individual boys and girls.

The developmental neuropsychology studies the behaviour consequences of lesions, malformations and disorders of the Nervous System, and an appropriate instrument for neuropsychological assessment of the children is NEPSY. In some studies with American samples, the authors (Korkman, Kirk & Kemp, 1998) affirm that NEPSY allows the evaluation of children with reading disorders, specifying that English-speaking children evaluated with this test manifest significantly lower scores in Language, Memory and Learning domains, and more specifically in Phonological Processing, Speeded Naming and Oromotor Sequences subtests

(Language Domain), and Sentence Repetition, Memory for Names and Narrative Memory subtests (Memory and Learning Domain).

Aims

The aim of this study is to determine the relations between the neuropsychological variables and the behaviour of the dyslexic children in a Spanish sample, and to check the effect of language variables, as language decoding, reported by recent authors.

The specific objectives are:

1. To check the possible significant differences between samples of dyslexic and reader children in raw scores of the NEPSY subtests.
2. To verify the capacity of different subtests of the NEPSY to discriminate between reader children and children with high probability of being diagnosed as dyslexic.
3. To check what are the domains and subtests of the NEPSY that have significant relationships with the performance in reading and writing variables of the Bongo Test in a sample of dyslexic children.

Method

Sample

The sample consists of 30 children from 7 to 11 years old classified into three groups:

1. Control group of 10 reader children.
2. Group of 10 children with low probability of being diagnosed as dyslexic.
3. Group of 10 children with probable, and very probable dyslexia, according to the criteria of Bongo Test (Aguilar, 2004).

There are 4 boys and 6 girls in the group 1, but in the groups 2 and 3, there are 6 boys and 4 girls. There are no statistical differences in mean age between group 1 (8.63 years) and 3 (8.90) (table 1), but the mean age in group 2 (10.86 years) is significantly different. It is for this reason that performance comparisons can be made only between the groups 1 and 3, and we make use of data from group 2 only for statistical regressions.

TABLE 1. DESCRIPTIVE STATISTICS IN THE GROUPS OF THE SAMPLE: AGE, DIFFERENCES OF AGE BETWEEN GROUPS, SEX, HANDEDNESS, AND SCHOOL LANGUAGE.

	Age *M (SD)*	***Mann-Whitney rank-sum test***	***Sex***		***Preferred hand***		***School language***
			Boys	*Girls*	*Right*	*Left*	
G 1	8,63(1,87)	$p_{G1\text{-}G2}$= .03*	4	6	8	2	100 % bilingual
G 2	10,86 (1,65)	$p_{G2\text{-}G3}$ = .02*	6	4	8	2	100 % bilingual
G 3	8,90 (1,50)	$p_{G1\text{-}G3}$ = .53	6	4	10	0	100 % bilingual

**Statistically significant difference*
Note: G1 (Reader children); G 2 (Low probability dyslexia); G 3 (Probable and very probable dyslexia)

According to information provided by children themselves, in group 1 and 2 there are 8 right-handers and 2 left-handers, and in group 3, all them are right-handers. All children of the global sample are bilingual in Catalan and Spanish.

Design

It is a differential and correlational design in which all measures are administered to all subjects.

Measures

– Independent variables (classification variables): Age (7-11 years old), sex (boys, girls), and group (1, reader children; 2, children with low probability of being diagnosed as dyslexic, and 3, children with probable, and very probable dyslexia).

– Dependent variables: Raw scores of the children in different NEPSY subtests, and the results obtained in reading and writing Bongo Test (Aguilar, 2004).

Instruments

The "NEPSY A Developmental Neuropsychological Assessment*"* (Korkman *et al.,* 1998) is a tool for developmental Neuropsychological Assessment and research. The NEPSY permits the assessment of five complex cognitive domains. Each of these domains is multifactorial. It is composed of subtests that measure possible contributory factors of a primary deficit, and thus understanding the selective subcomponents of each of the cognitive domains that may be differentially affected. We use the NEPSY Spanish version of the Department of Personality, Assessment, and Psychological Treatment at the University of Barcelona (Aguilar, Torres, Roldán, Mendoza & Sangorrín, work in process): "Nepsy. Una Evaluación

Neuropsicológica del Desarrollo". The subtests applied are specific for children from 5 to 12 years old. Classified by domains, these subtests are as follows:

– *Attention/Executive Functions*: Tower, Auditory Attention and Response Set, Visual Attention, Statue, Design Fluency, and Knock and Tap.
– *Language*: Phonological Processing, Speeded Naming, Comprehension of Instructions, Repetition of Nonsense Words, Verbal Fluency, and Oromotor Sequences.
– *Sensoriomotor Functions*: Fingertip Tapping, Imitating Hand Positions, Visuomotor Precision, Manual Motor Sequences, and Finger Discrimination.
– *Visuospatial Processing*: Design Copying, Arrows, Block Construction, and Route Finding.
– *Memory and Learning*: Memory for Faces, Memory for Names, Narrative Memory, Sentence Repetition, and List Learning.

The Bongo Test (Aguilar, 2004) evaluates the following literacy variables:

1. Writing variables:
   – Spelling mistakes (cultural errors, b/v; g/j, capital letters, etc.).
   – Writing errors (reversal, substitution, transposing letter sequences or syllables and errors of grammatical agreement).
2. Reading variables:
– Reading time.
– Reading errors.
– Wrong answers in reading comprehension test.

The Bongo Test is used to assess our criterion *"2. Impossibility or severe deterioration in reading that can affect to the writing"*. It presents differentiated performance tables in writing and reading for children from 7 to 14 years old, and they can be classified in normal reader, not very probable diagnosis of dyslexia, probable diagnosis of dyslexia, and very probable diagnosis of dyslexia. The children are selected by age and school year (Aguilar, 2004, tables 11 and 12, pages: 661-662).

Analysis techniques

Statistics: SPSS for Windows 14.0

Kolmogrov-Smirnov tests, Kurtosis, skewness and descriptive analysis were carried out to assess the assumption of normal distributions of the variables. In order to prove if the differences between groups are statistically significant, we carried out non-parametric analysis of Mann Withney for independent samples.

Then, we conducted a discriminant analysis procedure with the sub-samples of readers (group 1) and dyslexic children (group 3). Subsequently, linear regressions were performed in the groups 1 and 3 in order to check the effect of NEPSY variables on literacy performance.

Procedure

The sample was obtained with the consent of parents and teachers of the concerted public school Azorín in Hospitalet de Llobregat (Barcelona). First, the Bongo test was applied to all children of second to sixth course of primary school: Writing subtests in collective way, and reading task in individual way. From their results, we carried out the selection of children to form the different groups of the sample, in function of the tables of the Bongo test:

– Group 1, 10 reader children, selected at random of the explored readers.
– Group 2, 10 children with low probability of being diagnosed as dyslexic.
– Group 3, 10 children with probable and very probable diagnosis of dyslexia.

Next, they are applied to the three groups the expanded version of the NEPSY battery, and individual reports are aimed at teachers and parents. The mean time of the administrations of the NEPSY was 2 hours and 30 minutes.

Results

The descriptive analysis of the variables in the three groups presents a skewness that, in general, varies between -1 and 1; it is acceptable, although some of the NEPSY variables, such as Statue, reach the value of -2.227 in the Group 1. This group also shows some asymmetry in the subtests Knock and Tap, Imitating Hand Positions and Finger Discrimination (Preferred Hand). In the group 2, the variables with greater Asymmetry are: Auditory Attention and Response Set, Visual Motor Precision, Reading Time and Reading Errors. With regard to the group 3, the variables that present bigger skewness are: Statue, Design Copying, Block Construction, Writing errors, Reading Time and Wrong answers on the reading comprehension test. The explanation resides in the reduced number of subjects in each group and in the specific and strongly differentiated particularities of the subjects, especially in the variables related with reading and writing tests. On the other hand, the Kolmogrov-Smirnov test to evaluate the supposition of normality of the distributions of the scores of quantitative variables points to levels of significance >0.05 in all variables and in the three groups, therefore, we may to assume that these distributions have a normal tendency, in spite of some skewness results presented initially.

When comparing the performance of reader children (group 1) with the group 3, probable and very probable dyslexia (objective 1), we may see in table 2 the means and standard deviations of NEPSY variables in the three groups; but the table 3 presents the Mann-Whitney rank-sum U test of the NEPSY variables only of the groups 1 and 3. The differences in mean ranks (table 3) point to significant differences between groups in Tower, Knok and Tap, and Manual Motor Sequences with the significant better performance of reader children. The probable and very probable dyslexic children of the sample 3 only are superior to readers in Finger Discrimination non Preferred Hand (p=.015).

TABLE 2. MEANS AND STANDARD DEVIATIONS OF NEPSY VARIABLES IN THE 3 GROUPS.

NEPSY variables		***Group 1 N = 10***		***Group 2 N=10***		***Group 3 N = 10***	
		M	*SD*	*M*	*SD*	*M*	*SD*
Attention/ Executive Functions	Tower	15.20	1.75	14.40	1,65	12.90	1.97
	Auditory Att. & RS	95.60	19.90	99.30	11.45	86.50	10.92
	Visual Attention	15.00	4.88	17.90	5.47	15.3	3.83
	Statue	27,60	3.03			26.8	3.33
	Design Fluency	22.30	7.48			23.5	7.06
	Knock & Tap,	26.90	2.28			24.6	2.55
Language	Phonological Proc.	23.70	5.64	27.60	5.50	19.40	6.38
	Speeded Naming	21.80	9.90	32	6.88	24.60	9.23
	Compreh. Instructi.	20.80	1.93	21.40	2.55	19.40	3.06
	Repetition Nons. W.	32.00	5.25			30.20	3.52
	Verbal Fluency	38.10	11.88			39.90	10.40
	Oromotor Seq.	42.50	9.28			35.60	6.10
Sensorio-motor Functions	Fingertip Tapping	68.00	16.30	56.70	11.28	81.70	22.45
	Imitating Hand P.	18.90	2.51	20.7	2.11	18.50	2.07
	Visuomotor Preci.	21.90	7.52	32.7	5.98	26.60	8.15
	Manual Mot. Seq.	46.60	4.27			39.40	7.34
	Finger Discrim. PH	15.00	2.00			15.50	1.90
	Finger Discrim. NPP	14.10	1.79			16.30	1.70
Visuospatial Processing	Design Copying	59.80	7.69	61.60	3.56	58.10	8.33
	Arrows	19.60	5.62	21.30	2.41	20.60	4.20
	Block Construction	12.90	3.18			10.90	1.37
	Route Finding	6.60	2.88			7.90	1.66
Memory and Learning	Memory for Faces	25.70	3.47	24.80	4.89	23.00	4.76
	Memory for Names	20.10	6.17	22.40	4.14	19.70	5.29
	Narrative Memory	17.70	6.29	23.80	3.71	21.60	3.63
	Sentence Repetition	19.70	3.53			18.00	5.87
	List Learning.	49.43	13.53			43.30	16.01

Note: Group 1(Reader children); Group 2 (Low probability dyslexia); Group 3 (Probable and very probable dyslexia)

TABLE 3. MANN-WHITNEY RANK-SUM U TEST OF NEPSY VARIABLES IN THE GROUPS 1 & 3.

NEPSY variables		***Group 1 N = 10***	***Group 3 N = 10***	***Significance of the Differences***	
		Mean rank	*Mean rank*	*Z*	*p*
Attention/ Executive Functions	Tower	13.65	7.35	-2.42	.015*
	Auditory Att. & RS	12.30	8.70	-1.36	.19
	Visual Attention	10.25	10.75	-.19	.85
	Statue	11.45	9.55	-.73	.48
	Design Fluency	9.95	11.05	-.42	.68
	Knock & Tap,	13.20	7.80	-2.01	.04*
Language	Phonological Proc.	12.70	8.30	-1.67	.11
	Speeded Naming	9.60	11.40	-.68	.53
	Compreh. Instructi.	12.45	8.55	-1.50	.14
	Repetition Nons. W.	11.55	9.45	-.80	.44
	Verbal Fluency	10.40	10.60	-.08	.97
	Oromotor Seq.	12.85	8.15	-1.78	.075
Sensorio-motor Func-tions	Fingertip Tapping	8.70	12.30	-1.36	.19
	Imitating Hand P.	11.20	9.80	-.54	.63
	Visuomotor Preci.	8.55	12.45	-1.48	.14
	Manual Mot. Seq.	14.50	6.50	-3.04	.002**
	Finger Discrim. PH	9.80	11.20	-.54	.63
	Finger Discrim. NPP	7.35	13.65	-2.45	.015*
Visuospatial Processing	Design Copying	11.65	9.45	-.80	.44
	Arrows	10.35	10.65	-.11	.91
	Block Construction	12.70	8.30	-1.68	.105
	Route Finding	9.30	11.70	-.92	.39
Memory and Learning	Memory for Faces	12.05	8.95	-1.18	.25
	Memory for Names	10.35	10.65	-.11	.91
	Narrative Memory	8.40	12.60	-1.59	.12
	Sentence Repetition	11.75	9.25	-.95	.35
	List Learning.	10.57	7.90	-1.07	.32

**Statistically significant difference*
Note: Group 1(Reader children); Group 3 (Probable and very probable dyslexia)

To verify the differential profile between readers and dyslexic samples, it is carried out a discriminant analysis (objective 2) taking as independent variables the NEPSY subtests, and as dependent or grouping variable: Group (1, Reading group, $N = 10$) and 3, children with diagnosis of probable and very probable dyslexia, $N = 10$). Method: Stepwise Wilks' lambda; criteria for entry variables: F=3.84; and for to remove: 2.71. These F values represent significance levels of approximately .05 and .10 respectively. The result shows a Wilks' Lambda = 0.092, and high chi-square value = 28.667. The associated significance value $p <$ .001 indicates that the differences are significant.

The functions for groups are: G1 Reader children = -3.533; G3 Probable & Very probable dyslexia = 2.473. In Table 4 we display the list of 6 variables and their coefficients that are included by the Stepwise Wilks' lambda method in the discriminant equation. The results present a high canonical correlation 0.953 (the correlation between the discriminant scores and the levels of the grouping variable). The analysis shows that the equation correctly classifies the 10 reader children and the 10 with probable and very probable diagnosis of dyslexia, the 100% of the 20 cases.

In table 4, we may see the 6 Standardized Canonical Discriminant Function Coefficients. There is only one variable selected from the Language domain: Oromotor Sequences. It points to the greater ability of the readers compared to dyslexic children (means: 42.50 and 35.60); but, the difference is close to significance, according to Mann-Whitney U test: p= .075).

TABLE 4. STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

Oromotor Sequences	-.1.483
Fingertip Tapping	1.447
Visuomotor Precision	1.899
Finger Discrimination (no pref. Hand)	2.060
Arrows	1.615
Route Finding	-1.193

However, other selected variables (Fingertip Tapping, Visuomotor Precision, and Finger Discrimination non Preferred Hand) discriminate the superior ability of dyslexic children on readers, and belong to the domain of Sensoriomotor Functions, although only the later difference is statistically significant (p=.015). Moreover, Arrows and Route Finding belong to Visuoespatial domain and also are selected by the apparent greater ability of dyslexics on readers, but the differences are not significant (see tables 2 and 3).

For the objective 3, we find the effect of different NEPSY variables on reading and writing performance in the sample of children with literacy problems (Groups 2 and 3, N=20). To carry out the implementation of various multiple regressions analysis, we take as dependent variables each performance in reading and writing separately, and as independent, the set of NEPSY subtests. Method: Forward (Criterion: Probability of F to enter < .05).

Table 5 shows that Forward entry method selects different NEPSY predictors to form multiple regression equations on the writing dependent variable Spelling Mistakes and on writing Errors. According to our experience in previous research (Aguilar & Aguilar, 2004), the Spelling mistakes are cultural errors: In Spanish language, they are mistakes as to write b versus v, g versus j, the bad use of capi-

tal letters, the use of letter h, some errors of grammatical agreement, etc. It is an orthographic problem, and it is an ability that depends on variables as intelligence, cultural level, and schooling attained. On the contrary, what we call writing errors correspond to what years ago mistakenly some authors called dyslexic specific errors: It can be reversal, substitution and transposing of letters, sequences of syllables, etc. But, according to our previous research (Aguilar, 1977, 1981a, 1983), all children make such errors in the early stages of learning, but not all dyslexics finally manifest these writing errors (Aguilar, 1979), and if they do it, the kind of errors may vary in each child, depending on their personality traits and history (Aguilar & Aguilar, 2004).

TABLE 5. MULTIPLE REGRESSION ANALYSIS. PREDICTOR VARIABLES: NEPSY SUBTESTS. DEPENDENT VARIABLES: EACH ONE OF THE WRITING BONGO TEST. GROUPS 2 AND 3, *N*= 20

Bongo test	*NEPSY*	*R*	R^2	*Adjusted* R^2	*Signif F*
Spelling mistakes	Comprehension of Instructions; Memory for Names; Tower; Phonological Processing; Speeded Naming.	.835	.697	.589	.003
Writing errors	Memory for Names; Design Copying; Phonological Processing; Imitating Hand Positions; Speeded Naming.	.773	.597	.453	.016

Both equations (Signif *F*< .01) show some common variables: Memory for Names (Memory and Learning domain), Phonological Processing, and Speeded Naming (Language domain). But also, the dependent variable Spelling Mistakes has as a predictor Comprehension of Instructions (Language domain), and Tower (Attention/Executive Functions). Variables that depend largely on the level of acquired language and intelligence. And the dependent Writing Errors has as specific coefficients: Design Copying (Visuospatial domain), and Imitating Hand Positions (Sensoriomotor Functions), closest to some classical theories of dyslexia.

Table 6 presents the different multiple regression analysis with NEPSY predictors on the three reading dependent variables of the Bongo Test:

1. Reading Errors: Narrative Memory, Memory for Names, and Memory for Faces (Memory domain); Fingertip Tapping, and Imitating Hand Positions (Sensoriomotor Functions); Arrows, and Design Copying (Visuospatial Processing); Comprehension of Instructions, Phonological Processing, and Speeded Naming (Language domain).

2. Reading Time: Narrative Memory, Memory for Faces, and Memory for Names (Memory and Learning domain); Fingertip Tapping (Sensoriomotor Functions); Tower (Attention/Executive Functions); Phonological Processing, and Speeded Naming (Language domain).

3. Wrong answers on reading comprehension test: Comprehension of Instructions (Language domain).

TABLE 6. MULTIPLE REGRESSION ANALYSIS. PREDICTOR VARIABLES: NEPSY SUBTESTS. DEPENDENT VARIABLES: EACH ONE OF THE READING BONGO TEST. GROUPS 2 AND 3, *N*= 20

Bongo test	*NEPSY*	*R*	R^2	*Adjusted* R^2	*Signif F*
Reading errors	Narrative Memory; Memory for Names; Memory for Faces; Fingertip Tapping; Arrows; Design Copying; Imitating Hand Positions; Comprehension of Instructions; Phonological Processing; Speeded Naming.	.934	.872	.730	.006
Reading time	Narrative Memory; Memory for Faces; Memory for Names; Fingertip Tapping; Tower; Phonological Processing; Speeded Naming.	.834	.696	.519	.019
Wrong answers on reading comprehension test	Comprehension of Instructions.	.818	.669	.574	.021

Thus, the regression equations highlight the importance of language, according to other cited research, including Phonological Processing as predictor on writing and reading variables. Nevertheless, also appear other independent variables of the other four domains to create the formula to determine the predicted values on writing and reading Bongo Test.

The exception is Reading Comprehension, with only one logical NEPSY predictor: Comprehension of Instructions.

The selected variables have an understandable relationship with the behaveiour studied, as in the case of Fingertip Tapping, which directly affects the reader time, because both variables require the speed and accuracy of motor muscles and nervous system that provide the matuirity and training. Tower subtest is also saturated by the variable Time of Resolution of the Items, as well as the other selected variables.

Discussion and conclusions

The three objectives of the study have been met. But table 3 only presents the Mann-Whitney rank-sum U test of the NEPSY variables of the groups 1 and 3 by the significantly higher mean age of the children in group 2. The mean ranks point to significant differences between groups 1 (readers) and 3 (dyslexic children) in Tower, Knok and Tap, and Manual Motor Sequences with the significant better performance of reader children. The probable and very probable dyslexic children of the sample 3 only are superior to readers in Finger Discrimination non Preferred Hand.

The subtest Tower of the Attention and Executive Functions domain is similar to Tower of Hanoi, and this subtest has an important spatial component, since children have to introduce the colored balls in the right, left or central columns, depending on model. We have seen from past experience that some dyslexic children have problems with orientation and attention tasks (Felton & Wood, 1989), for example with the keys and digits Wechsler subtests, although show no significant differences in other tests of factor g, as "Cattell's Scale B" of the HSPQ (Aguilar & Aguilar, 2004). On the other hand, many dyslexic children have high levels of anxiety in tasks involving timer (Aguilar, 1981b), therefore their lower performance in these tasks is explained.

Knock and Tap is also a subtest of the Attention and Executive Functions domain. It is designed to assess self-regulation and inhibition. The child should use her preferred hand to tap on the table when the neuropsychologist knok and to knock when the neuropsychologist tap. It requires that the child maintain a specific cognitive set, involving the suppression of motor actions and the production of conflicting motor responses.

Manual Motor Sequences belongs to the group of the Sensorio-Motor Functions domain and it is designed to assess the ability to imitate a series of rhythmic movement sequences using one or both hands.

Finger Discrimination is also a subtest of the Sensorio-Motor Functions domain. This subtest is designed to assess the ability to identify fingers using tactile information. The neuropsychologist touches a finger of the subject hidden from view. The task is done twice: With the preferred and non-preferred hand. In this work, readers have a better performance on the task performed with the preferred hand, although the difference was not significant (table 3). Conversely, with non-preferred hand, are dyslexic children who have obtained a statistically significant better performance (p=.015).

After, we have verified the capacity of some NEPSY subtests to discriminate between the literacy performance of a sample of reader children and another of children with probability and high probability of being diagnosed as dyslexics, by means of a discriminant procedure: It has classified in the expected group the 10 reader children and the 10 diagnosed with probable and very probable dyslexia. In

Table 4, we display 6 NEPSY variables that are included by the Stepwise Wilks' lambda method in the discriminant equation: Oromotor Sequences, Fingertip Tapping, Visuomotor Precision, Finger Discrimination (no preferred hand), Arrows, and Route Finding. But, we may observe that other language variables as Phonological Processing subtest don't appear among those selected for the discriminant function, neither Repetition of Nonsense Words, although some definitions and current research found language previous problems in the origin of dyslexia, specially difficulties in single word decoding, and deficit in the phonological component of language (Goswami, 2002; Lyon, Shaywitz & Shaywitz, 2003). Of course, if the criteria for Method and entry variables was different, the selected variables would be more, although would not be correctly classified 100% of subjects.

The Oromotor Sequences subtest assesses the motility of the oral muscle coordination that subserves articulation and smooth, sequential production of speech sounds. In the task, the child repeats sound sequences (e.g., "split" "splat") and tongue twisters five times each. This variable is related to progressive maturity of the motor system. But perhaps, the increased capacity of the dyslexic readers in this test, as in other raised by other authors, such as the ability to decode, it could also be a consequence of reading training of the children who can read and not the previous cause.

To check the domains and subtests of the NEPSY that have significant relationships with the performance in the variables of reading and writing test of dyslexic children, we are carried out multiple regression analysis of the set of independent NEPSY predictors on each one of the dependent five writing and reading variables. The results show that the Forward entry method selects different sets of predictor variables of the NEPSY to form the regression equations on each of the dependent writing and reading measures. The subtests that have influence on Spelling Mistakes are 5 (Comprehension of Instructions, Memory for Names, Tower, Phonological Processing, and Speeded Naming) from the five NEPSY domains. On Writing Errors, repeated variables of language domain are: Memory for Names, Phonological Processing and Speed Naming; and are also selected Design Copying, and Imitating Hand Positions, logically related with acquired manual ability.

On Reading Errors are selected 10 NEPSY subtests, and 7 on Reading Time. It is obvious that reading ability depends on other very complex language activities related with the five NEPSY domains. We highlight the repeated selection of the language domain variables Phonological Processing, Memory for Names, and Speed Naming. They support those mentioned by precedent cited researchers (APA, 2000; Lyon, Shaywitz & Shaywitz, 2003; WHO, 2006). However on Reading Comprehension only one is selected as predictor variable: Comprehension of Instructions, subtest of the language domain obviously related.

Therefore, the predictors on reading and writing performance are different for each one of the variables studied. Phonological Processing and Speed Naming form part of the set, but they do not seem to be the most important to discriminate between groups. We can also see it by checking the significant differences between samples of dyslexic and reader children in raw scores of the NEPSY subtests by means of nonparametric Mann-Whitney Rank-Sum U test (table 3).

Our results are consistent with the suggestion of Shaywitz, Escobar, Shaywitz, Fletcher and Makuch (1992) that dyslexia may represent the lower tail of to normal distribution of reading ability, and also are consistent with those obtained by Crews and D'Amato (2010) with 80 reading disabled children. They completed only the subtests of language and memory domains, but three cluster s emerged witch were interpreted as: (1) a No Language or Memory Deficit Subtype, (2) a Global Language and Memory Deficit Subtype, and (3) a Global Memory Deficit Subtype. These authors suggested that memory-related processes, not exclusively phonologically-related processes, might contribute to reading difficulties, and they emphasize the utility of a neuropsychological approach to subtyping children's reading disabilities.

We may conclude that reading and writing tasks are very complex linguistic activities that indeed presuppose previous learning to learn, to understand and to express speech, and to acquire skills and knowledge to do it. Moreover, they require inner speech to achieve internal reading. Such activities require the maturation of brain areas related to the five domains studied, and sensorial and motor skills. Errors can be caused by immaturity or injury of the brain areas, sensorial or motor organs or by learning disabilities or even by personality and anxiety states.

When something fails, it is understood that also fails corresponding linguistic activity and that the fault is manifest by writing errors, bad reading comprehension, excessive reading time, etc. When the linguistic product of some activity is failed or erroneous, their functions are also lost or reduced. This is shown by our results (Aguilar & Aguilar, 2004).

However, our present work is a pilot research, which must be confirmed by a larger representative sample of Spanish population.

REFERENCIAS

Ackerman, P.T. & Dykman, R.A. (1995). Reading-disabled students with and without comorbid arithmetic disability. *Developmental Neuropsychology, 11*, 351-371.

Aguilar, A. (1977). *Dislexia* (Doctoral dissertation). Universidad de Barcelona, Spain.

Aguilar, A. (1979). Personalidad, lectura y escritura. *Revista de Psicología General y Aplicada, 158,* 521-541

Aguilar, A. (1981a). Rasgos de personalidad y comportamiento lector. *Revista de Psicologa y Pedagogía Aplicadas, 13*(25-26), 49-65.

Aguilar, A. (1981b). Respuestas vegetativas e instrumentales de lectores y disléxicos. *Universitas Tarraconensis, 3,* 81-104.

Aguilar, A. (1983). *La dislexia como respuesta*. Barcelona: Publicaciones y Ediciones Universidad de Barcelona.

Aguilar, A. (2004). Intervención en el comportamiento disléxico. In A. Aguilar & E. Aguilar (Eds.), *La persona con trastornos del lenguaje, la palabra y la voz* (pp. 653-685). Barcelona: PPU.

Aguilar, A. & Aguilar, E. (2004). Efecto de variables de personalidad y motivación sobre el desempeño en tareas cognitivas y de lectura y escritura en niños lectores y disléxicos. *Análisis y Modificación de Conducta, 30*(133), 693-725.

APA (2000). *DSM-IV-TR Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision*. Washington & London: Author.

Crews, K.J. & D'Amato, R.C. (2010). Subtyping children's reading disabilities using a comprehensive neuropsychological measure. *The International Journal of Neuroscience, 119,* 1615-1639.

DeFries, J.C. & Alarcon, M. (1996). Genetics and specific reading disability. *Mental Retardation and Developmental Disabilities Research Reviews*, *2*(1), 39-47.

Dickstein, P.W. & Tallal, P. (1987). Atentional capabilities of reading-impaired children during dichotic representatin of phonetic and complex nonphonetic sounds. *Cortex*, *23*(2), 237-249.

Felton, R.H. & Wood, F.B. (1989). Cognitive deficits in reading disability and attention deficit disorder. *Journal of Learning Disabilities*, *22*(1)*,* 3-13.

Francis, D.J., Fletcher, J.M., Stuebing, K.K., Lyon, G.R., Shaywitz, B.A. & Shaywitz, S.E. (2005). Psychometric approaches to the identification of LD: IQ and achievement scores are not sufficient. *Journal of learning Disabilities, 38*(2), 98-108.

Goswami, U. (2002). Phonology, reading development and dyslexia: A cross-linguistic perspective. *Annals of Dyslexia*, *52*, 141-163.

Goulandris, N. (Ed.)(2003). *Dyslexia in different languages*. London: Whurr Pub.

Grosser, G.S. & Spaffor, C.S. (1989). Perceptual evidence for an anomalous distribution of rods and cones in the retinas of dyslexics: A new hypothesis. *Perceptual and Motor Skills, 68*(3),683-698.

Gustafson, S., Samuelsson, S. & Rönnberg J. (2000). Why do some resist phonological intervention? A Swedish longitudinal study of poor readers in grade 4. *Scandinavian Journal of Educational Research, 44*(2), 145-162.

Katz, R. B. & Sevush, S. (1989). Positional dyslexia. *Brain and Language*, *37*(2), 266-289.

Kaufman, W.E. & Galaburda, A.M. (1989). Cerebrocortical microdysgenesis in neurological normal subjects: A histopathologic study. *Neurology*,*39*, 238-244.

Kayser, H.G. (1989). MBD: Diagnose eller Arbeidshypotese? (Minimal Brain Disfunction: Diagnosis or working hypothesis). *Tidsskrift for Norsk Psykologforening*, *26(5),* 305-311.

Korkman, M., Kirk, U. & Kemp, S. (1998). *NEPSY A Developmental Neuropsychological Assessment.* San Antonio: The Psychological Cor. Harcourt Brace & Co. Spanish version of the A. Aguilar, M. Torres, C. Roldán, E. Mendoza, and J. Sangorrín, *NEPSY. Una Evaluación Neuropsicológica del Desarrollo*. Barcelona: University of Barcelona, Department of Personality, Assessment and Psychological Treatment, (Work in process).

Korkman, M., Kemp, S.L. & Kira, U. (2001). Effects of age on neurocognitive measures of children ages 5 to 12: A cross-sectional study on 800 children from United States. *Developmental Neuropsychology, 20*(1), 331-354.

Lovegrove, W.J., Garzia, R. P. & Nicholson, S.B. (1990). Experimental evidence for a transient system deficit in specific reading disability. *Journal of the American Optometric Association*, *61*(2)*,* 137-146.

Lyon, G.R., Shaywitz, S.W. & Shaywitz, B.A. (2003). Defining dyslexia, comorbidity, teacher's knowledge of language and reading. A definition of dyslexia. *Annals of Dyslexia, 53,* 1-14.

Nix, G.W. & Shapiro, J. (1986). Auditory perceptual processing in learning assistence children: A preliminary report. *Journal of Research in Reading*, *9*(2)*,* 92-102.

Shapiro, B.K. (1996). The prevalence of specific reading disability. *Mental Retardation and Developmental Disabilities Research Reviews*, *2*(1), 10-13.

Shaywitz, S.E., Escobar, M.D., Shaywitz, B.A., Fletcher, J. M. & Makuch, R. (1992). Evidence that dyslexia may represent the lower tail of a normal distribution of reading ability. *New England Journal of Medicine, 326*(3), 145-150.

Shaywitz, B.A., Shaywitz, S.E., Blachman, B.A., Pugh, K.R., Fulbright, R.K., Skudlarsky, P. ... Gore, J.C. (2004). Development of left occipitotemporal systems for skilled reading in children after a phonologically-based intervention. *Biological Psychiatry, 55*(9), 926-33.

Tallal, P. (1999). Children with language impairment can be accurately identified using temporal processing measures: A response to Zhang and Tomblin. *Brain and Language, 69:* 222-239

Werker, J.F. & Tees, R.C. (1987). Speech perception in severely disabled and average reading children. *Canadian Journal of Psychology, 41*(1), 48-61.

Williams, M.C. & Lecluyse, K. (1990). Perceptual consequences of a temporal processing deficit in reading disabled children. *Journal American Optometric Association*, *61*(2), 111-121.

World Health Organization (2006). *International Statistical Classification of Diseases and Related Health Problems. 10th Revision*. *Version for 2006*. Author.