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Revista **EL**ectrónica de **I**nvestigación
y **EV**aluación **E**ducativa

THE ORTON'S HYPOTHESIS ABOUT HEMISPHERIC LATERALIZATION AND READING-WRITING PERFORMANCE REVISITED: AN *EX POST FACTO* STUDY IN SPANISH CONTEX

(La hipótesis de Orton sobre lateralización hemisférica y desempeño en lectoescritura revisada: Un estudio ex post facto en un contexto español)

por

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Abstract

This paper attempts to inquiry the connections between hemispherical laterality and reading-writing performance, based on the theory that Samuel T. Orton established over 60 years ago. No evidence has been found to show a significant correlation between both constructs. Therefore, the widely held belief that the one depends on the other can be refuted.

Keywords

ex post facto study, laterality, hemispheric laterality, Orton, reading, Spanish language, writing

Resumen

Este estudio trata de indagar qué conexiones existen entre los constructos: lateralidad hemísférica y desempeño en lecto-escritura en base a la teoría de Samuel T. Orton establecida hace unos 60 años. Ninguna evidencia se ha encontrado que muestre una correlación entre ambos constructos. Por tanto, la ampliamente adoptada creencia de que uno depende del otro puede refutarse

Descriptores

Estudio *ex post facto*, lateralidad, lateralidad hemisférica, Orton, lectura, idioma español, escritura

Abbreviations: **LD**: Learning Difficulties; **p**: probability value; **ES**: Effect Size; **R^2**: squared correlation coefficient; **H$_0$**: null hypothesis; **H$_1$**: alternative hypothesis; **G$_i$**: group or sub-sample; **n**: group size; **D.V.**: Dependent Variable; **I.V**.: Independent Variable.

Introduction

In science, it is relatively frequent that ideas should be challenged by new evidence just when they have been widely accepted. Therefore, this work will attempt to investigate this line of thought by means of a falsation study of a theory, which is deep-rooted in psycopedagogic practice.

In this work, the authors attempt to verify whether there is a connection between hemispheric laterality and reading-writing perform-

ance. It is well known that reading-writing disabilities are of primary importance in a Learning Difficulties (from now, LD) context, but it seems paradoxical that they are usually explained from different conceptions and points of view.

During the present century, different theoretical conceptions and explicative hypotheses of LD in reading-writing have developed which have a common denominator, the search for etiological factors that would define those deficits. It was found in Orton's works (1928a, 1928b, 1937, 1939), that these factors were due to a lack hemispheric cerebral dominance manifest in a lack of dominance in the lateralization of peripheral organs (hand, foot, eye, and ear). Hand use was the most representative and unmistakable, although inverted, symptom of cerebral hemisphere's activity. Orton (1939) gave the name estrephosimbolia to the syndrome in which insufficient development of cerebral dominance could cause confusion in reading and writing. According to his observations:

...Children who had difficulty with hand preference (lack of cerebral dominance) had mirrored writing and inverted letters when they read.

Orton's view supported the general idea that the etiologic reading-writing referents are attributable to sensorial-perceptive disabilities (cif. Boder, 1970; Kounios & Holcomb, 1994; Mycklebust & Johnson, 1962). A widely accepted contrary view states categorically that all reading-writing disorders are due to language, including metalinguistic disability (cif. Alegría, 1985; and Vellutino, 1987). The Ortonian model remits to an analysis of the etiologic referents of the cerebral-organic dysfunction, since, in last instance, it assumes that hemispheric cerebral laterality regulates the development of such reading-writing abilities.

Faced with such a variety of conceptions and different points of view, the authors subject to falsation Orton's theory. This theory structures a causal relation between laterality and reading-writing performance, and contributed to create a deep-seated belief in the minds of educators.

Problem: Identification and formulation

Research was done on the following generic problem: Is there any relation between laterality modalities and reading-writing performance? Or more precisely: Is there a high, statistically significant correlation between hemispherical laterality and reading-writing performance?

The problem appears at the academic level, in the schools, and more specifically in the educators´ mind. This is made clear by a survey amongst 80 elementary school teachers with a long experience in reading-writing teaching and Special Education (Machuca, 1996, pp. 194-202). The results obtained from the questionnaire showed that 95% of the "experts in Special Education" either agreed or deeply believed that a student with crossed laterality could have problems during the reading-writing learning process. More precisely, the number of self-defined "experts in the reading-writing teaching" who believed that a student with crossed laterality could have reading-writing LD was eight times greater than the number of "experts" who did not agree or deeply disagreed with that conclusion. In other words, many professional teachers attempt to justify their students´ reading-writing LD on the basis of their type, state or grade of laterality slightly holding the Orton-causation belief. Therefore, the authors have frequently heard anecdotal expressions such as:

-The problem is that s/he is left-handed.

-Unfortunately s/he has crossed laterality.

-The student is not yet laterally defined.

This conception is mainly based on Orton's case studies and it would be interesting to verify how this assumption penetrated the Spanish psyco-pedagogic world: a clue could be traced following Manga (1986), Navarro et al. (1990) and Romero (1984). In fact, Orton maintained the hypothesis that all the children with incomplete cerebral dominance not only have difficulties with reading and writing but also in speech and language. Previously, other authors had sensed that hypothesis as well (i.e. Hinshel-

wood, 1917) although they did not offer empirical data.

Objectives

This study has the following four main objectives:

- To answer the question mentioned above.

- To test how strong the laterality variable is consolidated in the sample group (subjects between 7-8 years old).

- To carry out in-depth research on the structure of a construct as complex as proficiency in reading-writing.

If it could be proved that there is a positive co-variation between laterality and reading-writing, there would be two new possible objectives. On the one hand, prediction parameters could then be established. On the other, laterality could be ma-nipulated or stimulated in the hope that reading-writing performance would increase, if there were a causal relation between the two.

Hypotheses

The study seeks to establish whether or not there is a significant difference between each of the dependent reading-writing variables and the independent variables, the different states and grades of lateralization

The basic hypothesis is formulated as a conjecture of no differences between groups conformed by the attributive variables proper of the laterality construct. The research hypothesis will be: There is no significant correlation between the student's reading-writing performance and his or her laterality. This general hypothesis will be broken down into the partial hypotheses summarised as follows in table 1:

TABLE I. *Series of hypotheses in course*

D.V. - I.V.	STATE	GRADE	STATE-GRADE INTERACTION	TYPES
ORAL READING	.	.	.	.
DICTATION WRITING	.	.	.	.
COPYING WRITING	.	.	.	.
READING COMPREHENSION	.	.	.	.
ORAL ARTICULATION	.	.	.	.
COMPOSITION	.	.	.	.

*: In columns are independents variables. In rows, dependents.

Each partial hypothesis is enunciated as null in the sense that no significant differences exist in the dependent variable of interest according to the independent variable considered; explicitly as following:

There is no significant difference in a variable relative to reading-writing performance (oral reading, dictation writing, copying writing, reading comprehension, oral articulation and composition) if the pupils have distinct hemi-

spheric lateralization (grade, state and types of laterality).

In fact, we have 24 hypotheses including those relative to interaction effects state by grade, so it may be a repetitive and tedious task enunciated all them.

The two-tail formulation as a null hypothesis has been chosen as more conservative than the unilateral statement that can be derived from Orton's prediction.

Reviewing the literature

The following descriptors were used to find bibliography for research on the authors' hypothesis: reading, writing, dominance, no dominance, laterality, preference, hand dominance, dichotic perception, dicaptic and taquitoscopy hemispheric asymmetry and educational research. This search was carried out in two sources: we found 410 references in ERIC and 89 papers in various other data bases, which had in one form, or another considered our idea.

Going through the material was complex and difficult for several reasons:

- Absence of standardised terminology

- The diversity of research methods used.

- The indiscriminate use of the same variable either as a predictive or a criteria variable.

- The complex system of measurement of any one variable: reading is generally used to measure at the nominal-dichotonomic level (dyslexic vs. non-dyslexic, good readers vs. poor readers) or at the interval level (using test scores). The same applies to the laterality variable.

The methods used in the reviewed studies were essentially descriptive and correlacional. They range from case studies to qualitative and quantitative observation, and include comparative analytical or ex-post-facto studies and even experiments. In the latter, the laterality variable was

stimulated through action programs (i.e. Oakland et al. 1998).

Only 147 works relative to the authors´ hypotheses have been selected from the references found in the retrieved sources. These documents have been submitted to an integrative revision through the "counting votes" meta-analytical technique, with the following results: studies which support Orton's prediction: 41%; which support it partially: 27%; and research that denies the prediction or counter-studies: 32%. Evidently, other meta-analytical approaches more compact for review the literatures would have been more convincing but such synthesizing over exceeded this study. Even data from a metanalysis (Obrzut et al. 1997) report about controversial patterns.

The lack of conclusive evidence leads us therefore to contrast this hypothesis in a Spanish school context, a geographical area that has not been covered by the research found by the authors.

METHOD

Sample and population

The target population will be Spanish school children of second year of Primary school. The available population was formed by ten primary schools belonging to a school district in the city of Jaén, in southern Spain. The sampling technique used was the non-randomised selection by one-stage cluster, being the stage four regular groups or whole classgroups easily accessible. This convenience sample was made up of 122 children between 7-8 years old who came from three different primary schools.

Since the sample was not random and part of it belonged to a depressed area, catalogued by the regional authorities of the Andalusian Autonomic Community as a priority area for educational improvement, the sample will have to be explained in he light of the following separate variables: sex (50%-50%), social and economic

level of the family (5%: high level; 46%: medium level; 38%: low; 11%: very low), academic achievement by the end of the year (81%: progress adequately; 19%: need to improve), sibling order (first-born: 24%; second-born: 31%; third-born: 18.5%; fourth-born and more: 26.5%), students' level of motivation to the teacher's assessment (high: 29.3%; medium: 26.7%; low: 44%), level of family involvement in the education process, in the teacher's opinion (high: 22.4%; medium: 25.8%; low: 51.8%), ethnic group (Hispanic: 90%; gypsy: 10%), and school absenteeism level (of 1-10 days a year: 52%; of 11-20: 15%; of 21 or more: 33%).

It is obvious that the sample can not be considered very representative, in that it was not obtained by random selection. The sample is largely categorized with a purpose merely descriptive, not explanatory, and for some practical reasons. For this kind of studies, Aliaga (2000) recommends the use of illustrative samplings; impressionists ones, such and as Cook and Campbell denominated them (1979). Samples guided by some specific theory (here, evidently, the Ortonian theory) instead of the randomised samples from large populations whose abandonment is formally rec-

ommended by Campbell (1986, p. 73), Mark (1986) and, in a special way, by Shadish, Cook y Houts (1986).

Variables

The sample group was first submitted to an ad hoc laterality test developed by the researchers using two standardised tests (mainly, Harris, 1978; and Oldfield, 1971). According to the results, the subjects were then classified in two groups:

- According to state of lateralization: into subjects with right side command, left side command and no command or crossed command.

- According to the grade of lateralization: into defined subjects and marked subjects, depending on the consolidation of the laterality.

By crossing the two previous categories, the six types of lateralization given in table 2 were obtained.

TABLE II. *Types of* lateralization *according to state and grade*

GRADE	STATE		
	TYPES	RIGHT COMMAND	NO COMMAND OR CROSSED
	DEFINED	G_1 (n* = 31)	G_3 (n = 25)
	MARKED	G_2 (n = 23)	G_4 (n = 40)

Measuring of the laterality variable was done on a nominal scale level. The authors only detected three subjects with left side command (two marked and one defined). Since this represented so small a sample, the subjects assigned to it will not be included in later analysis. This is one of the limitations of the study.

On the other hand, the subjects were measured according to the following reading-writing variables using ad hoc instruments elaborated by the authors:

- Oral or mechanical reading, which included nine items: perseverance, correction, syllabifica-

tion, punctuation, guessing, omission, line skipping, inverting, and speed.

- Dictation writing. Study of six items: mixing, addition, omission, substitution, inverting, and spacing.

- Copying writing. Study of fourteen items: mixing, addition, omission, substitution, inverting, spacing, reading between lines, irregular lines, size, pressure, overscript, time, fixations, and graphic praxis.

- Reading comprehension. Study of five items: comprehension in silent reading, comprehension in reading aloud, literal oral comprehension, semantic, and comprehension by the observer .

- Oral articulation. Study of the Spanish phonological code based on articulation errors.

- Composition. Study of eight items: content or lack of content, organisation of ideas, use of sentences, word joining, punctuation, rules of phoneme-grapheme conversion, spelling of irregular words, and use of various types of letters (capitals, small, and).

The different reading-writing performance variables were measured at the interval level, except for the articulation variable that was measured at the nominal scale level.

Instruments

In the study of instruments, the following considerations have been developed relative to origin, type and format of the instrument used and associated measurement errors. The authors also tried to indicate the validity of the content and to approach the validity of construct through a factorial analysis of principal components.

At the same time, the reliability of each instrument was determined by three indexes: Cronbach's α, Carmines´Θ and Hoyt´coefficient. The latter was calculated according to values from an ANOVA of repeated measures: subjects measures: subjects (random) and items (fixed). The minimum coefficient was never below 0.75.

The different instruments that measured reading-writing performance were constructed by the researchers (ad hoc instruments), from sources taken from other authors and adapted to the object of our study. This decision was taken after the standardised tests available in Spanish language (i.e. TALE, EDIL I, BADIMALE,...) were analysed and it was found that they did not adjust to the objective of our study. This was because of insufficient measurement of items, which they did not contemplate and due to the absence of certain above-mentioned items mainly relative to comprehension and articulation. Therefore, the reading-writing production and responses of each student was assessed according to a rating scale that oscillated between 1 and 5. Two raters, working independently and with previously established criteria as to the number of errors, inconsistencies or other disabilities, gave a standardised value from 1 to 5 for each item. The unit of analysis is a score for an individual in each item and additive variable.

The laterality instrument used was based on Harris' test (1978) and expanded with items on manual laterality taken from Oldfield (1971) . Its reliability was tested by the test-retest procedure and for a two-year period using the Cohen´s weighted kappa (Kw). The value obtained was Kw of 0.82, which discounts the agreement due to chance. This value in itself is a finding of this research, in the sense that because it is highly reliable, especially in state and types, it can be inferred that hemispherical laterality is established by the age of eight, contrary to Lenneberg's hypothesis (1967/85), which establishes it at puberty.

Another important result of this research is evidenced when each of the principal components of the main variables or reading-writing domains is submitted to a factorial solution. This indicates that each main variable has an unequivocal single factor structure, which

gives coherence to the total additive value that will be used later.

Design

The design is typically ex post facto, since the independent variable laterality has been measured but not manipulated. Since this variable is given metrically for the categories usually found on a nominal scale (2 or 4 categories), this study can also be considered a comparative-correlacional study (Frankel & Wallen, 1990). If any significant co-variation between laterality and the reading-writing variables were to be found, the authors would try to infer causality based on a regression model, which would control alternative explicative variables.

The factorial structure of the design (2 x 2) and the size of each type would be as shown in table 3:

TABLE III. *Research design and sample sizes*

GRADE	STATE		
	TYPES	**RIGHT COMMAND**	**NO COMMAND OR CROSSED**
	DEFINED	G_1 (n* = 31)	G_3 (n = 25)
	MARKED	G_2 (n = 23)	G_4 (n = 40)

*n: group size

The present hypothesis intends to prove the following effects:

- Main effects according to the state: $G_1 + G_2$ vs. $G_3 + G_4$. This would be the contrast contesting Orton's hypothesis.

- Main effects according to grade: $G_1 + G_3$ vs. $G_2 + G_4$

- Effects of state x grade interaction: $G_1 + G_4$ vs. $G_2 + G_3$

- Simple effects: G_1 vs. G_2 vs. G_3 vs. G_4, for which multiple comparison procedures would have to be used.

Threats to validity of design and their control

The possible threats to the validity of the design will now be given (Table 4), all of which refer to its internal validity. On the other hand, since the sample used is not probabilistic, reference as to the external validity of the design is omitted and consequently any generalisation based on the findings of this study would be very risky. General techniques for controlling or minimising these threats are exposed.

TABLE IV. *Threats to the internal validity of design and its grade of plausible control*

THREATS	C.G	WAY OF CONTROL
Subjects' characteristics	[=]	- It is assumed that the characteristics would be shared uniformly between comparative groups. - Wide sample (n>100). - Groups of students in regular classes.
Location in the administration of instruments	[+]	- Constance and similarity. Individualised administration in three very similar office rooms.
Instruments decay	[+]	- Some interpretations are not possible from the emitted answers. - The value of the answers is highly standardized. - Two observers determine laterality in confusing cases.
Collector characteristics	[+]	- Two collectors solve the discrepances jointly.
Data collector bias	[+]	- The collecting procedures are standardized: Same instruments applied to every subject. - Two administrators collect data and solve discrepancies jointly.
Researcher expectative bias	[+]	- The dynamic of the work does not allow do this threat, as the instruments were firstly administered and afterward collected. This avoids that the previous knowledge of results can bias data to the level of the expectative of the researcher.
Testing	[+]	- The instruments whose measures will be correlated are different. They are given in different moments and contexts. - No pre-test.
Mortality	[+]	- Unrecorded cases of mortality would be excluded. - Intensive tracing of cases with fear of attrition. - Subjects with left dominance are excluded.

*: C. G.: The Control Grade is indicated like [+]: high; [=]: medium [-]: low.

Data analysis

Data analysis was done with the BMDP computer program, version PC/90 (Dixon, 1990). The authors have followed the guidelines for analysis and the statistical tests suggested by Shavelson (1988) and Fernández Cano (1995) for this kind of study.

Multiple contrasts have been used for each hypothesis. At the descriptive level, by using the effect size (ES) and correlacional statistics on the magnitude of the strength of association (correlation ratio, or quadratic η, or R^2, and other indexes). At the inferential level, univariate statistical tests (ANOVA) have been used, on the additive variable, and multivariate (MANOVA), with the different items taken as a multiple dependent variable. In each case the most liberal and lower p value has been preferred, in order to allow for differences of statistical significance. Therefore, we count with

three statistical tests: effect size (ES), explained variance (R2) and p values obtained on a fixed effects model. It is evident that, since the sample was not obtained by random selection, the result inferred can only be used as a guide and does not define. As manifested by Fernández Cano (1995, pp. 197-203) it is the reader who must give meaning and substance to the figures on the basis of what has been exposed.

RESULTS

According to the present hypothesis and in order to come to a decision on them, the criteria has been as follows:

- High significance [+++] is when there are three empirical values greater than the value of the established criteria.
- Medium significance [++] is when there are only two empirical values that exceed the criteria.
- Low significance [+] is when only one empirical value exceeds the criteria.

- Without significance [-] is when no empirical value exceeds the marked theoretical one, not rejecting the null hypothesis.

The critical or theoretical values are the ones that are socially accepted. So, it will be said that there is some significance rejecting the null hypothesis when: $ES > 0.5; R^2 > 0.05$ or $p < 0.05$.

Since in an article of this kind space is limited, all of the partial contrasts will not be given. Only a sample contrast will be offered, with a summary of the global results further on. For a detailed and exhaustive study of the contrast tests used in the study for all the hypotheses, see Machuca (1996, pp. 306-462).

Hypothesis on the main effects of lateralization on oral reading

Table 5 shows the statistical contrasts for the hypothesis that there are significant differences in the main variable of reading aloud depending on the grade of lateralization of the subjects.

TABLE V. *Statistical tests for the hypothesis relative to main effects for laterality state on oral reading performance*

I.V.	D.V. ORAL READING					
	ITEMS	ES	R^2	p	DECISION	ORTON
S T A T E	*Perseverance*	.10	.00	.99	H_0	No
	Correction	.35	.02	.09	H_0	No
	Syllabification	.06	.00	.92	H_0	No
	Punctuation	.21	.017	.14	H_0	No
	Guessing	.04	.00	.87	H_0	No
	Omission	.18	.00	.61	H_0	No
	Line skipping	.04	.00	.88	H_0	No
	Inverting	.01	.00	.51	H_0	No
	Speed	.01	.00	.51	H_0	No
	Additive total	1.4	.00	.88	H_0	No

By observing the pattern of results obtained for the hypothesis contrasting reading-writing performance with the grade of lateralization of the subjects, it can be seen that:

- At sample level, for any one item or for the sum total, the ESs calculated are lower than the accepted critical, 0.5.
- The statistic which marks the strength of association shows that its magnitude is negligible and without significance, since in no case is it higher than a value of 0.05, which would be a minimum, but socially accepted, percentage of explained variance (5%), obtainable from a minimal correlation of 0.22.
- At an inferential level, there are no p values, which denote statistical significance for any test, because they are all over 0.05.

The null hypothesis (H_0) is therefore not rejected and the authors affirm that there are no significant differences in oral reading performance depending on the grade of lateralization of the subjects compared: $G_1 + G_2$ (with right laterality dominance) versus $G_3 + G_4$ (without or with crossed laterality dominance).

To summarise, we affirm that, on a descriptive level or inferential level, no significant differences can be found in the students' oral reading performance or in any of its components dependent on whether they have defined themselves laterally or not. This affirmation goes against Orton's hypothesis regarding laterality that has gone unchallenged for six decades.

Hypothesis on the main effects of the grade of lateralization grade on oral reading

The hypothesis that relates the grade of laterality (defined as opposed to marked) with oral reading performance can be contrasted on the basis of the statistics contained in Table 6.

TABLE VI. *Statistical tests for the hypothesis relative to main effects for laterality grade on oral reading performance*

I.V.	D.V. ORAL READING					
	ITEMS	ES	R^2	p	DECISION	ORTON
G R A D E	*Perseverance*	.02	.00	.83	H_0	No
	Correction	.02	.00	.92	H_0	No
	Syllabification	.08	.001	.54	H_0	No
	Punctuation	.05	.001	.63	H_0	No
	Guessing	.03	.00	.89	H_0	No
	Omission	.05	.001	.73	H_0	No
	Line skipping	.00	.00	.86	H_0	No
	Inverting	.01	.00	.79	H_0	No
	Speed	.03	.00	.85	H_0	No
	Additive total	-.03	.00	.85	H_0	No

It can be seen that, both on the descriptive level or the inferential level, there are no empirical values higher than the critical values. Therefore, it can be stated that no significant differences can be found in the student's' oral reading performance or in any of its components dependent on whether they present a defined or a marked grade of lateralization. Consequently, the authors accept the null hypothesis (H_0) and reject the prediction originating from Orton's proposal.

By accepting H_0, the authors affirm that are no fully significant differences in oral reading performance in relation to the lateralization grade present in the subjects compared, G1 + G3 (with defined lateralization) and G2 + G4 (with marked lateralization).

Hypothesis relative to the effects of the interaction between the state x grade of lateralization on oral reading

Given the factorial structure of the present design in course, an interaction hypothesis can be contrasted to determine the differential behaviour of the independent variables in course. The statistical tests of this hypothesis are offered in table 7.

TABLE VII. *Statistical tests for the hypothesis relative to interaction effects for laterality grade by state on oral reading performance*

I.V.	D.V. ORAL READING					
	ITEMS	ES	R^2	p	DECISION	ORTON
INTERACTION STATE X GRADE	*Perseverance*	.16	.002	.62	H_0	No
	Correction	.13	.00	.88	H_0	No
	Syllabification	.22	.011	.24	H_0	No
	Punctuation	.11	.004	.50	H_0	No
	Guessing	.23	.013	.22	H_0	No
	Omission	.05	.001	.76	H_0	No
	Line skipping	-.22	.007	.33	H_0	No
	Inverting	.14	.002	.61	H_0	No
	Speed	.41	.038	. 03	H_1 [+]	Yes
	Additive total	0.26	.017	.16	H_0	No

Firstly, the null hypothesis is rejected after an inferential contrast (p = 0.03) showing that both independent variables interact in the speed item. According to the preciously established criteria, it can be said that there are differences of low significance. The fact that there is the possibility of an interaction hypothesis shows that the defined right side subjects (G1) and the marked crossed subjects (G4) read faster than the marked right side subjects (G2) and the defined crossed subjects (G4).

Although for this item the alternative hypothesis is accepted, for the remaining components and the sum total the null hypothesis is accepted and it can be affirmed that there are no significant differences between the groups compared. This is one of the few null hypotheses that are rejected in the study.

Hypothesis on the simple effects of lateralization types on oral reading

Taking four pre-established types (groups of subjects with a certain specific lateralization) the authors intend to demonstrate whether there are significant differences between them. In order to do so, the pertinent statistical tests presented in the table 8 were calculated.

TABLE VIII. *Statistical tests for the hypothesis relative to simple effects for laterality types on oral reading performance*

I.V.	ITEMS	ES*	R^2	p	DECISION	ORTON
	D.V.ORAL READING					
T Y P E S	*Perseveration*	*	.020	.96	H_0	No
	Rectification	*	.025	.47	H_0	No
	Syllabification	*	.013	.62	H_0	No
	Punctuation	*	.028	.24	H_0	No
	Guesswork	*	.013	.68	H_0	No
	Omission	*	.010	.92	H_0	No
	Interlineation	*	.008	.81	H_0	No
	Inversion	*	.002	.29	H_0	No
	Speed	**0.51**	.040	.19	H_1 [+]	Yes
	Additive total	*	.018	.56	H1[+]	No

ESs lower than 0.5 and obtained by *post hoc* multiple comparations are indicated with: *

Once again an ES of sufficient magnitude, 0.51, can be seen for the speed item. More specifically, it could be said that there is a low significance for groups G_1 and G_3. This finding indicates that the right side defined subjects (G_1) read faster than the defined crossed subjects (G_3).

We think that this evidence, difference in speed, was what started and sustained Orton's hypothesis in the past. The rationale for that could lie based on the fact that Orton used the two types of subjects in whom differences in laterality were marked the most (right side defined with a very strong laterality, as opposed to marked crossed, whose laterality was subject to variation before becoming defined). Moreover, it is very possible that two very accepted isomorphisms of that time may have been assumed. One, that reading performance was equivalent to reading me-

chanically and aloud. The other, that reading mechanically was equivalent to reading quickly. This double isomorphic assimilation was manifested in Spanish sayings that are still used in colloquial language, such as:

- *Lee de* corrido [S/he reads in one breath],

- *Lee como* un *papagayo* [S/he reels it off parrot-fashion]

indicating that the ability to read is the same as reading aloud very quickly. Evidently, mechanical or oral reading performance can not be measured according to speed. See how that main variable is treated in the present study.

For the remaining items and the sum total, H_0 is accepted and Orton is conclusively rejected.

DISCUSSION

Summary of findings

The remainder of the present hypothesis relative to the main dependent variables: copying, dictation, reading comprehension, composition, and articulation, and the different items are part of them, have received the same treatment as the oral reading variable explained above. It was a question of discovering whether there were any differences in each of them, according to their state, grade, the interaction between both and their type of lateralization. The results are very similar to those mentioned above in the results section. For more details see Machuca (1996; pp. 306-464).

Table 9 shows a summary of the findings for the variables in course.

TABLE IX. Statistical tests for the hypotheses relative to the variables studied according to the diverse lateralization modalities

ADDITIVE TOTALS												
	STATE			TYPES			GRADE			INTERACTION		
VARIABLE	ES	R^2	p	ES*	R^2	p	ES	R^2	p	ES	R^2	p
Oral reading	.14	.00	.88	<.50*	.018	.56	-.03	.00	.85	.26	.017	.16
Dictation	-.25	.016	.19	*	.028	.43	.00	.03	.88	.26	.016	.19
Copying	-.01	.00	.94	*	.008	.81	-.11	.004	.47	.13	.004	.51
Comprehension	-.12	.003	.52	*	.003	.29	-.05	.001	.77	.35	.029	.07
Articulation	.19	.008	.40	*	.014	.64	.07	.00	.88	.08	.001	.80
Composition	.00	.00	.99	*	.022	.49	-.09	.00	.66	.30	.000	.12

*: No one of the *ESs* between types (groups) for the additive total goes over the critic value (0.5)

For any reading-writing variable considered in our study, the sizes of effect calculated are lower than the accepted criteria (0.5). The statistics that mark the strength of the association is slight and without any significance, less than (0.05). The calculated **p** values, both the univariate statistics on the sum total or the multivariate tests on the items or components taken as a group, are above the acceptable level of significance ($\alpha = 0.05$). Therefore, with these figures it can be

stated that neither on a descriptive or on an inferential level are there any significant differences between the reading-writing domains object of the present study, dependent on whether the students presented different states, types or grades of laterality. This is summarised in table 10.

TABLE X. *Summary of findings adjusted to the Orton's prediction about reading-writing variables according to diverse modalities of lateralization*

V. D. - V. I.	STATE	GRADE	INTERACTION	TYPE
ORAL READING	NO	NO	NO	NO
DICTATION WRITING	NO	NO	NO	NO
COPYING WRITING	NO	NO	NO	NO
READING COMPREHENSION	NO	NO	NO	NO
ORAL ARTICULATION	NO	NO	NO	NO
COMPOSITION	NO	NO	NO	NO

Conclusions

The results of the various tests lead the authors to definitely reject Orton's hypothesis because there is no correlation between reading-writing performance and hemispheric lateralization. Therefore, it can be stated that learning of the reading-writing domains does not depend on the different aspects/types of laterality that a given subject may present (defined right, marked, crossed, with dominance or without dominance). Since no co-variation is detected between the criteria variables and the prediction variables that were considered, there is no sense in looking for causation in the present study, excluding possible alternative explanatory hypotheses. Our finding is opposite to other obtained in Spanish context by Hernández et al. (1997); they say that children with dominance to the same hemisphere (convergent cerebral organisation) were better readers (speed, accuracy and comprehension) than were children with no dominance (unconvergent organization). We think that they obtained lateral dominance using only hand preference.

Consequently, the authors sustain that the origin of reading-writing LD should be researched from other fields of knowledge since they are not imputable to the modality lateralization as Samuel T. Orton proposed (1937, 1939). This does not mean that the authors underestimate Orton, whose relevance has increased at the same pace as the society he promoted (The Ortonian Society, established in the United States), which is dedicated to the study of the student of LD in reading-writing. A Henry's paper (1998) provides a selective biography of Orton, discusses his educational ideas and how they came to be, and considers how current educational research validates much of Orton's early thinking.

However, the belief, firmly lodged in teachers' minds, that attributes reading-writing LD to the student's varying states, grades, or kinds of laterality, is unfounded. Therefore, it makes no sense to talk of training programmes for consolidating hemispheric lateralization in Spanish contexts. In view of their findings, the authors suggest that the students be allowed to freely decide which hand or limb they would

rather use, not only in reading-writing, but also in any other activity.

However, at school there can be situations of confusion for the teachers or a certain degree of anxiety in the family when the time comes to choose which hand will be the best for a determined task. When these doubts arise, the following must be taken into account:

- Respect the child's preference in choosing which hand to write with.

- Parents and teachers should refrain from favouring the use of one hand over the other before they have gathered enough information as to the rate of use of a certain limb, how long it is used, performance and quality in tasks performed with either hand: speed, graphic performance, and how the object is held. Only once all the above information was taken into account could guidance be given.

- Analyse the graphic evidence before deciding which hand should be preferred.

- Observe whether the child feels reluctant to use one hand rather than the other.

- Observe how long the child has favoured one hand over the other. This could indicate how counterproductive it could be to guide him/her towards using the other hand.

The common denominator of these suggestions is the intention of avoiding negative attitudes towards learning to read and write. Which hand the child decides to use should not be a source of worry for parents or teachers.

Suggestions for further research

Reading and writing is a learning process consisting of a series of elements. First, before the child enters school, there is the language element. Second, the ability to perform flexing and extension movements with the right hand in right handed children, and fortunately, today in left handed children as well, who tend to be able to draw the graphemes. Third, the capacity to discern space and configuration visually. These three superior cerebral functions which constitute the phonological and semantic codes, visual and spatial perception and manual praxis, result in the ability to learn to read and write. This implies that research into the causes of reading-writing problems should focus on these elements and not on the different models of cerebral organisation.

The choice of the dependent variables, which constitute the object of the present study, has not been the product of chance. The authors believe that they should be the guidelines to the diagnosis of reading-writing LD. The authors assume that different higher cerebral functions take part in the development of each variable. These must be studied and compared, sometimes separately, in order to understand the nature of LD, always based on the pathological facts. When referring to pathological facts, the authors would like to indicate that the pathology provides a breakdown of the elements that constitute the normal learning process, which can then be studied separately. The pathology enlarges the role of certain factors of the learning process that are not seen so clearly when they make part of a normal situation.

Consequently, the model that the authors propose, which involves a profound paradigmatic change, will lead to a physic-pathological diagnosis of school codes such as reading-writing and mathematics. The process would consist of a study of the level of the student's activity (competence) in each of the dependent variables proposed in the present study, and then to compare them two by two. The lowest level in achieving the variables would indicate the pathogenic profile of the disability, this is, the cerebral function/s that are obstructing an element of the reading-writing learning process. Only when this information has been obtained will all the conditions needed to help the student be met.

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Revista ELectrónica de Investigación y EValuación Educativa (RELIEVE)

[ISSN: 1134-4032]