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Gender ratio and cognitive profiles in dyslexia: a cross-national study

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Abstract The purpose of this study was to analyze possible gender-related differences in the prevalence of dyslexia. A cross-national comparison of Spain and Guatemala was conducted. Both countries speak the same language but have a different standard of living and educational level. A second purpose of this study was to analyze the cognitive profile of Guatemalan and Spanish males and females children with dyslexia. The log-linear analysis indicated that the number of dyslexics detected was different across the countries but there were no differences as a function of

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gender. Similarly, there were no significant or meaningful differences between dyslexic males and females in the cognitive processes involved in reading. Therefore, gender differences do not appear to be characteristic of developmental dyslexia.

Keywords Dyslexia · Gender · Cross-national studies · Cognitive processes

Introduction

Research focusing on gender ratio in developmental dyslexia has traditionally been assumed that there are more dyslexic males than females (Miles, Haslum, & Wheeler, 1998). A greater preponderance of males is identified when clinically based criteria for dyslexia are applied; typically have two to three boys to each girl (Miles et al., 1998; Vogel, 1990). Some hypotheses have been proposed to account for this gender difference in the case of school-identified children. For instance, Shaywitz, Shaywitz, Fletcher, and Escobar (1990) suggested that teachers were more likely to refer boys as having special problems, because boys were perceived as more disruptive than girls. Similarly, this selection bias might also apply to the clinic population where boys were more likely to be referred for service, as that boys may be more disruptive than girls (Chan, Ho, Tsang, Lee & Chung, 2007).

However, in research-defined samples, the ratio of boys to girls is usually much lower than in referred samples, although still slightly above a one-to-one ratio (Share & Silva, 2003). The inconsistency in gender differences is possibly the result of definitions used by different studies. In particular, the discrepancy definition of dyslexia or reading disabilities (RD) has introduced a gender bias such that boys with a RD are more likely to be identified than girls with RD (Share & Silva, 2003; Siegel & Smythe, 2005; Stuebing, Fletcher, LeDoux, Lyon, Shaywitz, Shaywitz, 2002). Therefore, the higher incidence of dyslexia among boys than among girls has been interpreted as an artefact of the participation selection processes or the statistical methods used in many research studies (Lubs, Rabin, Feldman, Jallad, Kushch, & Gross-Glenn, 1993; Share & Silva, 2003; Shaywitz et al., 1990; Wadsworth, DeFries, Stevenson, Gilger, & Pennington, 1992). Nevertheless, other authors have found evidence that boys were two to three times more likely to be affected than girls, regardless of the identification methods applied (DeFries, 1989; Flannery, Liederman, Daly, & Schultz, 2000; Katusic, Colligan, Barbaresi, Schaid, & Jacobsen 2001; Liederman, Kantrowitz, & Flannery, 2005; Rutter et al., 2004).

In addition to attributing such differences to definitional and criterion differences, the differences in estimated rates have to be viewed in the context of many other factors (see Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008; Snowling, 2000). Some of these factors are the nature of orthography and environment influences. As Chan et al. (2007) have noted there are significant differences in the estimation of prevalence rates and gender ratios in developmental dyslexia in different language settings. The transparency/opacity of the writing system has been suggested as a major variable affecting the level of difficulty in learning to read (e.g., Ziegler & Goswami, 2005). Italian, Spanish and Greek are examples of transparent orthographies (Seymour, Aro, & Erskine, 2003). A transparent orthography is one in which there is a predictable and invariant phoneme/grapheme correspondence. In the United States, estimates of incidence of children with RD vary from 5 to 10% (Shaywitz, 1998) to as high as 17.5% (Beier, Simos, Fletcher, Castillo, Zhang, & Papanicolaou, 2003). In Spain, Jiménez, Guzmán, Rodríguez and Artiles (2009) have recently reported a 3.2% of incidence of dyslexia in a transparent orthography.

Moreover, population-based studies did not control for environment influences and further research is needed on how environment factors could be causing or might be instrumental in overcoming gender differences in written language (Berninger et al., 2008). In this sense it has been hypothesized that girls may be less susceptible than boys to environmental factors, such as quality of teaching, social class differences, or outside pressures (Geschwind, 1981).

Spain and Guatemala are countries with the same language but cultural, political, and educational differences, and differences in the gender disparity and inequality opportunities. Each year since 1990 the Human Development Report (United Nations Development Programme, 2007) has published the Human Development Index (HDI) that provides a composite measure of three dimensions of human development: living a long and healthy life (measured by life expectancy) being educated (measured by adult literacy and school enrolment at the primary, secondary and tertiary level) and having a decent standard of living (measured by purchasing power parity and income). The HDI for Spain is 0.949 which gives the country a rank of 13th out of 177 countries, while the HDI for Guatemala is 0.689 which gives the country a rank of 118th out of 177 countries. The gender-related development index (GDI) measures achievements in the same dimensions using the same indicators as the HDI but captures inequalities in achievement between women and men. It is simply the HDI adjusted downward for gender inequality. Spain's GDI value was 0.944 and that means that it is 99.5% of its HDI value. Out of the 156 countries with both HDI and GDI values, 57 countries have a better ratio than Spain's. With regard to Guatemala's GDI value was 0.675. Its GDI value is 98% of its HDI value. Out of the 156 countries with both HDI and GDI values, 126 countries have a better ratio than Guatemala.

Based on the above studies, the preponderance of boys over girls in developmental dyslexia has been largely studied for the English language with ambiguous findings. Focusing on a cross-national study based on neither clinic referred nor school-referred samples, the present study has been designed to test whether or not consistent gender imbalance applies to a different language from English and a transparent orthography. Therefore, comparisons were made in two countries with the same language but differences in the gender disparity and inequality opportunities. In addition, we analyzed gender differences, not only in literacy skills but also in reading-related cognitive abilities among children with dyslexia.

Overall, we have not found studies focusing on a cross-national comparison of dyslexia examining gender ratio and cognitive profiles in a transparent orthography. First of all, we analyzed the gender-related differences in the prevalence of dyslexia in Guatemala City and the Canary Islands region of Spain. A second purpose of this study was to analyze the cognitive profiles of Guatemalan and Spanish males and females children with dyslexia, testing whether there are differences in reading-related cognitive abilities. We assessed the possible gender imbalance in developmental dyslexia, and whether gender differences in cognitive abilities might account for such imbalance.

Method

Setting

Data from the Spanish sample were collected in the Canary Islands. The Canary Islands has a population of just over 1.9 million people with an economy based in tourism and construction, and this region has experienced a high growth rate in recent years; in most of the economic indicators, the gap between the Canaries and the rest of Spain has been reduced. Data on the Guatemalan sample were collected in Guatemala City, the capital of Guatemala. This capital has approximately 2.5 million people, which accounts for 22% of the country's total population (Instituto Nacional de Estadística de Guatemala, 2003). According to Coope and Theobald (2006), Guatemala has a long history of violence where thousands of lives and communities were destroyed by displacement and disappearances. As a result of endemic poverty, Guatemala's children suffer from high rates of morbidity and mortality largely as a result of infectious diseases. In addition, there are high levels of child malnutrition. Twenty-five percent of under 5-year-olds are severely underweight, and 46% of these suffer from moderate to severe stunting (UNICEF, 2001a, b).

Educational legislation in Guatemala states that "Learning Problems" are diagnosed when the individual's achievement on individually administered standardized tests in reading, mathematics, or written expression is significantly below that expected for age, schooling, and level of intelligence (IQ) (MINEDUC, 2001). As has been noted by Artiles and Pianta (1993), special education programs for students with LD in Guatemala were created in the 1980s, are based on service delivery models in the United States, and the Federal Register (1977) definition of LD was adopted. In Spain, learning disabilities are conceptualized differently. Jiménez and Hernández-Valle (1999) concluded that an LD category, as has been defined by the National Joint Committee on Learning Disabilities (1994), does not exist in Spain. Special educational needs or LD in Spain, as in some other European countries such as the United Kingdom (McLaughlin et al., 2006), are identified when a pupil does not learn in the ordinary classroom setting and the teacher observes a difference between that pupil and the rest of the class's attainment regarding learning in subjects like reading, writing, and arithmetic. Recently, however, the last publication of *Ley Orgánica* 2/2006, May 3, of Education (LOE) uses the term Specific Learning Disabilities (SLD) but there is no clear definition of LD.

Participants

The Spanish participants were drawn from state and private schools in urban and sub-urban areas in the cities of Santa Cruz de Tenerife and La Laguna. Of the 1,048 children in the Spanish sample, there were 630 boys and 418 girls with ages ranging from 7 years, 9 months to 12 years, 8 months ($M = 113.8$ months, SD = 17.6). The 209 grade 2 students (120 boys, 89 girls) averaged 90.1 months in age (SD = 4.0). In grade 3 ($N = 198$; 115 boys, 83 girls), the mean age was 101.0 months (SD = 4.9). Fourth grade students averaged 113.6 months (SD = 4.7; $N = 216$ from 125 boys and 91 girls). The average for the 216 5th graders (136 boys, 80 girls) was

125.8 months (SD = 4.7). And, the average age for students in grade 6 (137.6 months, SD = 5.8) was calculated from 209 children (134 boys and 75 girls).

The Guatemalan sample was also drawn from state and private schools in urban and sub-urban areas in the Guatemala City. Of the 557 children in the Guatemalan sample, there were 316 boys and 241 girls with ages ranging from 8 years, 8 months to 14 years, 7 months ($M = 134.5$ months, SD = 16.1 months). The average age of the 156 grade 3 participants (92 boys, 64 girls) was 117.3 months (SD = 10.0). The mean age for 4th graders ($N = 143$; 78 boys, 65 girls) was 129.1 months (SD = 8.2). The average grade 5 age was 141.7 months (SD = 7.2) for the 131 students (75 boys, 56 girls). And, the average age for the 6th graders (154.2 months, SD = 7.1) was calculated from 127 children (71 boys and 56 girls).

We selected the same proportion of state and private schools (3:1) located in similar urban and sub-urban areas in both countries but there were differences in the number of classrooms per grade in Guatemalan and Spain schools. Therefore, the number of children selected in Spanish schools was greater than in Guatemalan schools.

In order to analyze the gender differences in cognitive abilities among Guatemalan and Spanish dyslexics we established two reading level groups, dyslexics and normally achieving readers. The cut-off percentiles established were sample-dependant for each country and the norms used obtained both in Spain and Guatemala. Children with dyslexia were those who meet the following criteria: (a) the absence of sensory, acquired neurological and other problems traditionally used as exclusionary criteria for learning disabilities, (b) a percentile score below 25 on accuracy on pseudoword reading from naming task of the Spanish Standardized Multimedia Battery SICOLE-R (Jiménez et al., 2007), or a percentile above 75 on reading time on pseudoword or word reading from naming task of the Sicole-R, and (c) an IQ > 75 to exclude students with intellectual deficits (Siegel & Ryan, 1989). Word reading tests, as opposed to reading comprehension tasks, yield the clearest definition of normal and atypical reading. Typically, a reading score at or below the 20th or 25th percentile is used. Good or average readers are defined as having score on reading test at or above the 30th, 35th or 40th percentile. It has confirmed the differences between normally achieving readers and dyslexics (Siegel, 2003; Siegel & Ryan, 1989). However, a discrepancy between reading achievement and IQ was not included in our definition of dyslexia. There is empirical evidence that traditional IQ-based discrepancy formula may introduce a gender bias such that boys with a RD are more likely to be identified than girls with RD (Share & Silva, 2003; Siegel & Himel, 1998; Siegel & Smythe, 2005). Normally achieving readers were identified through the following criteria: (a) reading comprehension equal or above the 50th percentile; (b) a percentile score above 25 on accuracy on pseudoword reading from naming task of the Sicole-R; (c) a percentile below 75 on reading time on pseudoword or word reading from naming task of the Sicole-R; and (d) an IQ > 75. Children with neurological disorders or sensory deficits, language impairments, and general developmental delays were also excluded from the final analyses.

Means and standard deviations for all the identification measures as a function of nationality, gender and reading level are given in Table 1.

There were significant differences in age between Spanish sample and Guatemalan sample F (1, 973) = 60.2, $p < 0.001$, $\eta^2 = 0.23$. With regard to

Table 1 Means and standard deviations of IQ, age, pseudoword naming task (accuracy), pseudoword naming task (time), word naming task (time), reading comprehension as a function of nationality, gender and reading level

Nationality	Reading level	Gender	*N*		IQ	Age	PW	PWT	WT	RC
Spain	Normally achieving readers	Males	273	Mean	105.77	117.12	0.94	1,456.15	1,154.60	0.77
				SD	14.07	17.20	0.07	468.58	397.30	0.12
		Females	*196*	Mean	104.61	112.88	0.93	1,532.41	1,205.82	0.76
				SD	13.89	16.54	0.07	451.33	394.18	0.11
	Dyslexics	Males	*98*	Mean	97.19	114.86	0.85	1,909.30	1,659.39	0.47
				SD	12.53	16.28	0.13	567.19	549.05	0.11
		Females	*66*	Mean	98.18	111.62	0.85	1,958.40	1,677.39	0.48
				SD	12.81	16.77	0.12	504.42	497.91	0.10
Guatemala	Normally achieving readers	Males	*132*	Mean	99.84	134.79	0.92	1,659.80	1,288.34	0.76
				SD	14.31	17.03	0.08	565.84	436.96	0.10
		Females	*104*	Mean	101.39	136.03	0.92	1,552.24	1,206.58	0.78
				SD	14.65	14.96	0.09	534.27	376.98	0.10
	Dyslexics	Males	*65*	Mean	93.92	134.05	0.79	2,122.32	1,658.48	0.51
				SD	12.17	15.63	0.12	606.30	464.30	0.11
		Females	*45*	Mean	90.96	136.07	0.83	2,001.34	1,600.93	0.51
				SD	9.89	16.19	0.10	616.88	368.29	0.10

Note: *IQ* Intellectual quotient, *PW* pseudoword naming task accuracy, *PWT* pseudoword naming task time, *WT* word naming task time, *RC* reading comprehension

IQ, we found that Spanish sample had higher IQ scores than Guatemalan sample F (1, 977) = 23.3; $p < 0.001$, $\eta^2 = 0.02$, and also normally achieving readers had higher IQ scores than dyslexics F (1, 977) = 60.2, $p < 0.001$, $\eta^2 = 0.06$.

Instruments

Culture fair (or free) intelligence tests

Also known as a measure of *g*, (Scale 1 and 2, Form A; Cattell & Cattell, 1989). It is a nonverbal test designed to measure analytical and reasoning ability in the abstract and novel situations. The test includes mazes, classifications, conditions and series. The authors that conducted the Spanish adaptation used the split-half method to calculate reliability and reported a correlation coefficient of 0.86. They used as validity criteria scores on the TEA-1 test (Test de Aptitudes Escolares) (Seisdedos, De la Cruz, Cordero, & González, 1991). The TEA-1 test has three factors: Verbal, Reasoning, and Calculation. A correlation coefficient of 0.68 was found between the *g* factor measure and results on the TEA-1 test that measured verbal, reasoning, and numerical aptitudes.

Spanish Standardized Multimedia Battery SICOLE-R (Jiménez et al., 2007). The SICOLE-R is a computer-based assessment system for the diagnosis of reading disabilities in the Spanish language. This Standardized Multimedia Battery includes different modules. These modules are as follows:

The *Phonemic Awareness* module evaluates the child's ability to manipulate the sounds or phonemes of spoken words and consists of four tasks. An average score was calculated by adding the correct responses in the four tasks, and dividing that sum by the number of tasks. The tasks administered were the following:

In the *Isolation* task, the child listened to a word (e.g., *lana/wool/*), and was required to say its first sound (/l/). Then, he or she had to point to the picture (with the computer mouse), that began with that same sound (in this example, *luna*/moon/). There were 15 items in this task, and the reliability coefficient was 0.75.

The child listened to a word in the *Segmentation* task (e.g., *rana/frog/*) and then to say its constituent sounds, phoneme by phoneme (i.e.,/r//a//n//a/). Either pronouncing the sounds or saying the names of letters constituted a correct response. There were 15 items in this task, and the reliability coefficient was 0.80.

In the *Deletion* task, the child listened to a word (e.g., *blusa/blouse/*) and then was required to delete its first sound. The child responded by using the mouse to select the correct choice from three available options (in this case, *lusa* from /lusa/, /tusa/, and /musa/). There were 15 items, and the reliability coefficient was 0.83.

The child listened to a sequence of phonemes (e.g.,*/m//e//s//a/*) in the *Blending* task and was required to say the whole word (*mesa*/table/). There were also 15 items in this task, and the reliability coefficient was 0.86.

The aim of the *Speech Perception* task was to evaluate listeners' ability to discriminate consonant contrasts in the context of syllables. The stimuli-pairs recordings were produced by a phonetically-trained, Spanish female speaker. There are three different tasks: (a) voicing contrast, (b) manner of articulation contrast, and (c) place of articulation contrast. The inter stimulus interval was 1 second and the maximum inter-trial interval was 5 s. To control for guessing rates, a derived score was calculated by subtracting the proportion of incorrect responses from the proportion of correct responses. This derived score was used in all accuracy analyses (range = 0–1) and the reliability coefficient was 0.95.

The *Naming Speed Task* was adapted from Denckla and Rudels' *Rapid Automatized Naming Ta*sk (1974). This task required the sequentially naming of two series of letters and numbers, and two series of colors and common objects as quickly as possible.

The *Naming Task* consists of reading aloud each of the verbal stimuli (words or pseudowords) that appeared one by one on a computer screen. The response time to each stimulus was registered from the moment when the word or pseudoword appeared on the screen until the child pronounced the first sound. The sound was recorded by the voice key, which stopped the computer's chronometer. The sequencing in the administration of the stimuli was as follows: blank screen on the computer (200 ms), fixation point in the center of the screen (400 ms), stimulus word or pseudoword. In total, the time between items was 2,000 ms. Average scores were used for the correct responses obtained in the word naming and pseudoword naming tasks. We only used pseudoword accuracy scores and word and pseudoword naming latency times of correct responses to establish the two reading level groups, dyslexics and normally achieving readers. The reliability coefficients were 0.80 and 0.83, respectively. Average scores were also calculated for the latency times of correct responses for words and pseudowords. The reliability coefficients were 0.89 and 0.91, respectively.

The *Orthographic Processing* module of the Sicole-R used a homophone selection task. In this 14-item task, participants were presented with a picture, two homophone words (e.g., *orca/killer whale/*, *horca/gallows/*) and a spoken question (e.g. what is an animal?). In this example the h is silent in Spanish. The children had to choose one of the written words matched the picture and the question. The reliability coefficient was 0.76.

In the root morphological comprehension task of the *Morphological Processing* module, the child was presented with a written word and two pictures, one of which corresponded to the word (e.g., the word *casita/small house/*) and two pictures (large house-small house). The child was required to read the written word out loud and point to the correct picture. Four different root morphemes were used (e.g., *casa*, *casita*, *casas*, *casitas*). Each word changed the suffix on the same root during four presentations. The root morphemes were always meaningful units of words but never words in themselves. The suffixes did not change the grammatical class and inflexion provided information about number and grade. Twenty items were administered and the reliability coefficient was 0.92. An average score of latency times for correct responses was calculated for this task.

The *Syntactic-Semantic Processing* module consisted of six tasks which evaluated the proper use of gender and number agreement rules, proper use of function words and their involvement in assigning syntactic roles, and children's execution of tasks using their knowledge of the syntactic structure of a sentence. An average score from the mean of the six tasks was calculated. These six tasks were:

Children were presented with truncated sentences in this module's *use of gender* task. They read the words in the sentence and words which were proposed as alternatives for properly completing the sentence. Each blank space was accompanied by two words differing in gender, only one of which would correctly complete the sentence (e.g., The___/*silla/sillón- seat/*is quite____/*cómodo,cómoda-confortable*). Nouns and adjectives that refer to them must agree in gender in the Spanish language. There were 12 items in this task and the reliability coefficient was 0.78. The *use of number* task was identical except that the words presented as alternatives for completing the sentence differed in number (e.g., The___/*camisa*, *camisas -shirt*, *shirts*/are____/*rota*, *rotas -spoiled*). Nouns and adjectives that refer to them must agree in number in the Spanish language. There were 12 items and the reliability coefficient was 0.82.

Two sentences and one picture were presented in the *word order* task. The child was required to indicate which sentence corresponded to the picture. Sentences had a subject-verb-object structure. The two alternative answers varied in that the subject and object roles were reversed (e.g., el niño peina a la niña- the boy combs the girl; la niña peina al niño- the girl combs the boy). There were 12 items and the reliability coefficient was 0.60. The *correct use of assigning syntactic roles* task was similar to the word order task. A picture and a series of three sentences were presented, only one of which corresponded to the image. Two of the sentences were active; they differed in that one had a subject-verb-object syntactic structure, the other an object-verb-subject structure (e.g., la moto es seguida por el camión, al camión le sigue la moto, la moto sigue al camión/the motorcycle is followed by the truck, the truck it follows the motorcycle, the motorcycle follows to the truck/). The third alternative was a sentence in the passive voice. There were 12 items in this task and the reliability coefficient was 0.73. In the *function words* task, the exercise consisted of presenting a sentence where one word was missing. Below the sentence were two function words and one noun; only one of the function words will properly completed the sentence (e.g., Juan se bebió dos botellas de agua porque tenía ____/*poca*/*mucha*/*refresco*/*sed*) (Juan drank two bottles of water because he was ____/*little*/*much*/*soda*/*thirsty*). There were 12 items and the reliability coefficient was 0.77.

The *Punctuation signs*, task of the Syntactic-Semantic Processing module, involved a short text with missing punctuation signs. The child was required to place the correct signs (i.e., period, comma, question mark, exclamation point, etc.) and in the correct places using the computer mouse. The reliability coefficient was 0.86.

Reading comprehension test

The comprehension task consisted of a 10-item test that measured the ability to abstract the meanings of a given text using the 135-word narrative and a 197-word descriptive passage. Participants were asked to answer five questions pertaining to each text displayed on a computer screen, and they could not look back at the text. Questions had three possible response options; participants were prompted to choose the correct option and respond using a mouse. The measure was the average number of questions correctly answered and the reliability coefficient was 0.63.

Fluency task

The total time of narrative text reading divided by the number of words was used as a measure of fluency.

Working memory test

To assess children's working memory, we administered a task adapted for the Spanish language from Siegel and Ryan (1989). In this task, children listened to sentences that were missing the final word. The task consisted of supplying the missing word and then repeating all the missing words from the set. For each level or set size, the score was 1 if the student performed the task successfully, and 0 score if he or she failed. There were three trials at each level of set size (2, 3, 4, and 5 words). Task administration was stopped when the child failed all the trials at one level.

Procedure

At this point it is important to bear in mind that Sicole-R was adapted to Guatemalan population. The Guatemalan adaptation process consisted in reviewing idiomatic expressions and vocabulary characteristic of the Spanish used by Guatemalan people, and all pictures used in the software program were also adapted so that they could be recognized by Guatemalan children. Experienced psychologists conducted the administration of the Sicole-R Multimedia Batery (Jiménez et al., 2007), reading, verbal working memory, and IQ tests. They were unaware of the group status of the children. The assessments were conducted individually during four sessions per child in quiet rooms provided by the schools that the children attended. The tasks were presented randomly, each being preceded by two examples to ensure that the children understood the instructions.

Results

Gender ratio of developmental dyslexia in Guatemalan and Spanish children

In the Spanish sample there were 630 male and 418 female (ratio: 1.5:1) ($N = 1.048$). A total of 164 Spanish children were identified with dyslexia (98 male and 66 female). This represents 15.6% of the total sample of 1,048 students. From Spanish LD population, 9.3% were male, and 6.3% were female. The odds ratio indicated that Spanish male dyslexics were 1.5 times more likely to be detected than Spanish female dyslexics. In the Guatemalan sample there were 316 male and 241 female (ratio = 1.3:1) ($N = 557$), and 110 students, or 19.9% of the 557 children, were identified as dyslexics (65 male and 45 female). From Guatemalan LD population, 11.7% were male, and 8.1% were female. The odds ratio indicated that Guatemalan male dyslexics were 1.4 times more likely to be detected than Guatemalan female dyslexics (see Fig. 1).

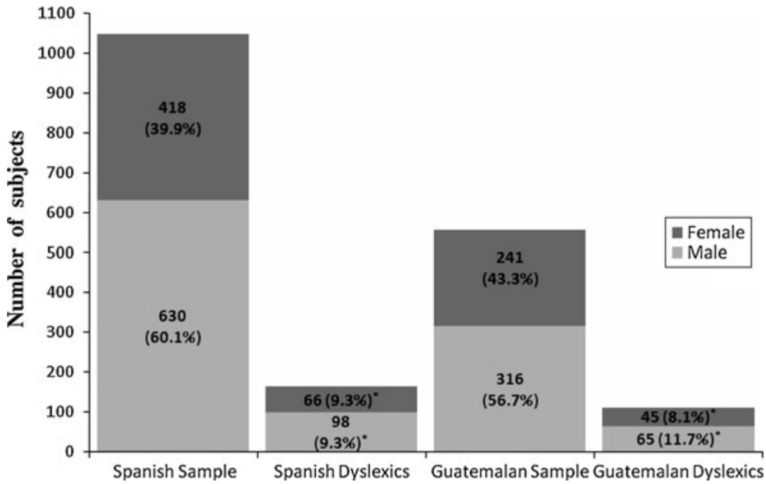

Fig. 1 Frequencies and percentage corresponding to each country sample as a function of gender, nationality and reading level. *Percentage corresponding to each country sample

In the total sample there were 946 male and 659 female (ratio: 1.4:1). The sample identified with dyslexia was 163 males and 111 females (ratio: 1.4:1). The odds ratio indicated that dyslexic males were 1.4 more likely to be detected than dyslexic females.

Analysis

The nonparametric analysis appropriate for the examination of higher order interactions among several discrete variables is the log-linear analysis (Dancer, Anderson & Derlin, 1994). This analysis involves fitting a log-linear model to the observed cell frequencies of a cross-classification table to obtain the most parsimonious yet adequate description of the distribution of the data (see Tracey, Sherry, Bauer, Robins, Todaro, & Briggs, 1984 for a description more complete).

The three-way log-linear analysis produced a final model that retained the Nationality × Group. The likelihood ratio of this model was $\chi^2\,(3) = 2.04, p = 0.56$.

The Nationality × Group interaction was significant χ^2 (1) = 51.60, $p < 0.001$. The interaction indicated that the number of dyslexics detected was different across the countries. The odds ratio indicated that Guatemalan dyslexics were 1.3 times more likely to be detected than Spanish dyslexics. The Gender effect was also significant χ^2 (1) = 4.24; $p < 0.05$. Examination of the contingency tables revealed that the proportion of males was greater than females in the total population (ratio 946:659). The cross-classification tables are reported in Table 2.

Table 2 Cross-classification of Spanish and Guatemalan children as a function of gender and reading level

			Group					
			Dyslexics			Normally achieving readers		
			Gender		Total	Gender		Total
			Males	Females		Males	Females	
Nationality	Spain	*N*	98	66	164	532	352	884
		Expected frequencies	98	66	164	520	364	884
		% Nationality	60	40	100	60	40	100
		% Gender	60	59	60	68	64	66
		% Overall	36	24	60	40	26	66
	Guatemala	*N*	65	45	110	251	196	447
		Expected frequencies	65	45	110	263	184	447
		% Nationality	59	41	100	56	44	100
		% Gender	40	40	40	32	36	34
		% Overall	24	16	40	19	15	34
Total		*N*	163	111	274	274	548	1,331
		Expected frequencies	163	111	274	783	548	1,331
		% Nationality	59	40	100	59	41	100
		% Gender	100	100	100	100	100	100
		% Overall	59	40	100	59	41	100

Gender differences in cognitive abilities among Guatemalan and Spanish children with dyslexia

As seen in the sample description, significant differences in age and IQ existed between the reading level groups (dyslexics and normally achieving readers). For this reason, analyses of covariance (ANCOVAs) were performed. Before performing the ANCOVAs, we examined the influence of age and IQ and the goodness of their use for this type of analysis. In the case of IQ it was not possible to control this variable for fluency and word naming accuracy, because it did not fulfil the assumption criteria of the ANCOVA. Nevertheless, there is empirical evidence that IQ is not relevant for differentiating children with and without RD (see Jiménez & Rodrigo, 1994; Jiménez, Siegel, O'Shanahan, & Ford, 2008; Siegel, 1992 for a review). In the case of age, it was not possible to use it as a covariate for word naming accuracy and morphological processing tasks. Thus, we conducted an analysis of covariance (ANCOVA) via general linear model for the following fixed factors: gender (male vs. female), nationality (Spain vs. Guatemala), and reading level (dyslexics vs. normally achieving readers) and dependent variables: phonological awareness, speech perception, naming speed, syntactic processing, orthographical processing, working memory, fluency, and morphological processing. Means and standard deviations by reading level groups for all measures are given in Tables 3 and 4. Table 5 shows analysis of covariance results for cognitive processes.

Table 3 Means and standard deviations of phonological awareness, speech perception, naming speed, syntactic processing, homophone comprehension as a function of nationality, gender and reading level

Nationality	Gender	Reading level		PA	SP	NS	S	H
Spain	Males	Normally achieving readers	Mean	0.80	9.18	35,628.20	0.78	0.82
			SD	0.11	1.19	8,903.40	0.14	0.15
		Dyslexics	Mean	0.67	8.61	43,151.61	0.60	0.70
			SD	0.15	1.49	10,662.32	0.18	0.18
	Females	Normally achieving readers	Mean	0.77	9.21	37,489.44	0.78	0.80
			SD	0.12	1.05	8,677.93	0.14	0.15
		Dyslexics	Mean	0.65	8.85	43,241.82	0.63	0.71
			SD	0.15	1.08	8,788.36	0.16	0.17
Guatemala	Males	Normally achieving readers	Mean	0.78	8.93	37,799.79	0.73	0.82
			SD	0.12	1.47	8,575.30	0.15	0.11
		Dyslexics	Mean	0.65	8.64	40,357.74	0.58	0.74
			SD	0.13	1.39	11,161.46	0.14	0.14
	Females	Normally achieving readers	Mean	0.81	9.31	36,909.19	0.78	0.84
			SD	0.11	0.92	9,035.99	0.13	0.10
		Dyslexics	Mean	0.67	9.03	43,444.67	0.63	0.78
			SD	0.10	0.84	10,428.02	0.11	0.12

Note: *PA* phonological awareness, *SP* speech perception, *NS naming speed*, *S* Syntactic processing, *H* Homophone comprehension

Table 4 Means and standard deviations of working memory, fluency, Word naming task accuracy, morphological processing as a function of gender, nationality and reading level

Nationality	Gender	Group		WM	F	WN	M
Spain	Males	Normally achieving readers	Mean	2.26	618.64	0.99	1,667.56
			SD	0.84	352.13	0.02	527.37
		Dyslexics	Mean	1.82	985.37	0.96	2,110.81
			SD	0.66	858.45	0.12	603.38
	Females	Normally achieving readers	Mean	2.07	768.88	0.99	1,725.91
			SD	0.74	477.03	0.02	537.44
		Dyslexics	Mean	1.71	921.45	0.97	2,027.96
			SD	0.66	457.33	0.04	563.05
Guatemala	Males	Normally achieving readers	Mean	2.48	662.31	0.98	1,691.22
			SD	0.98	308.72	0.03	502.99
		Dyslexics	Mean	2.20	799.98	0.95	2,122.63
			SD	1.03	341.48	0.06	550.95
	Females	Normally achieving readers	Mean	2.31	635.10	0.99	1,613.76
			SD	0.97	307.88	0.03	501.17
		Dyslexics	Mean	1.98	809.97	0.97	2,225.25
			SD	0.78	453.94	0.04	633.30

Note: *WM* working memory, *F* fluency, *WN* word naming task accuracy, *M* morphological processing

The cognitive processes measured by accuracy measures are represented in the Fig. 2, and the cognitive processes measured by processing time measures are represented in the Fig. 3.

Both main effects of nationality and reading level were significant. These main effects indicated that Spanish children scored higher in phonological awareness, speech perception, syntactic processing, and homophone comprehension when they were compared with Guatemalan children, and also the scores for the normally achieving readers were significantly higher than dyslexics in phonological awareness, speech perception, syntactic processing, homophone comprehension, working memory, and morphological processing. Also a significant main effect of gender revealed that females scored higher than males in speech perception, syntactic processing, homophone comprehension, and word naming accuracy, except in working memory tasks where males did better than females. For naming speed task, the analysis yielded a significant main effect of nationality and reading level, but both effects were subsumed under a significant nationality × gender × reading level interaction. Test of simple main effects confirmed that there were differences between males and females, and between nationalities for normally achieving readers, F (1, 971) = 4.6, $p < 0.05$, although this difference was not significant for dyslexic children, F (1, 970) = 1.6, $p = 0.166$. For fluency task, a main effect of reading level and nationality were significant. But both effects were

Table 5 Analysis of covariance (ANCOVA) results for cognitive processes

	Covariates		Reading level	Nationality	Gender	Group × Nationality × Gender
	IQ	Age				
Phonological Awareness	F (1, 969) = 108.4***	F (1, 973) = 227.6***	F (1, 966) = 147.9*** ($\eta^2 = 0.13$)	F (1, 966) = 11.5*** ($\eta^2 = 0.01$)		
Speech Perception	F (1, 681) = 20.0***	F (1, 680) = 43.7***	F (1, 963) = 10.2*** ($\eta^2 = 0.01$)	F (1, 963) = 13.6*** ($\eta^2 = 0.01$)	F (1, 963) = 10.8*** ($\eta^2 = 0.01$)	
Naming Speed	F (1, 966) = 12.6***	F (1, 964) = 80.1***	F (1, 965) = 49.6*** ($\eta^2 = 0.05$)	F (1, 965) = 26.8*** ($\eta^2 = 0.15$)		F (1, 965) = 4.9* ($\eta^2 = 0.005$)
Syntactic Processing	F (1, 967) = 107.4***	F (1, 968) = 361.3***	F (1, 967) = 188.5*** ($\eta^2 = 0.16$)	F (1, 967) = 97.1.3*** ($\eta^2 = 0.09$)	F (1, 967) = 19.9*** ($\eta^2 = 0.02$)	
Homophone comprehension	F (1, 965) = 29.6***	F (1, 963) = 166.2***	F (1, 962) = 51.9*** ($\eta^2 = 0.05$)	F (1, 962) = 6.4* ($\eta^2 = 0.01$)	F (1, 962) = 4.4*** ($\eta^2 = 0.005$)	
Working memory	F (1, 917) = 25.3***	F (1, 915) = 166.9***	F (1, 920) = 18.9*** ($\eta^2 = 0.02$)		F (1, 920) = 5.9* ($\eta^2 = 0.01$)	
Fluency		F (1, 967) = 272.6***	F (1, 967) = 41.7*** ($\eta^2 = 0.04$)	F (1, 967) = 25.9*** ($\eta^2 = 0.03$)		F (1, 967) = 4.4* ($\eta^2 = 0.005$)
Word naming accuracy			F (1, 969) = 70.5*** ($\eta^2 = 0.07$)		F (1, 970) = 3.9* ($\eta^2 = 0.004$)	
Morphological processing	F (1, 958) = 23.1***		F (1, 958) = 94.0*** ($\eta^2 = 0.09$)			

Note: *IQ*, Intellectual quotient

* $p < 0.05$; *** $p < 0.001$

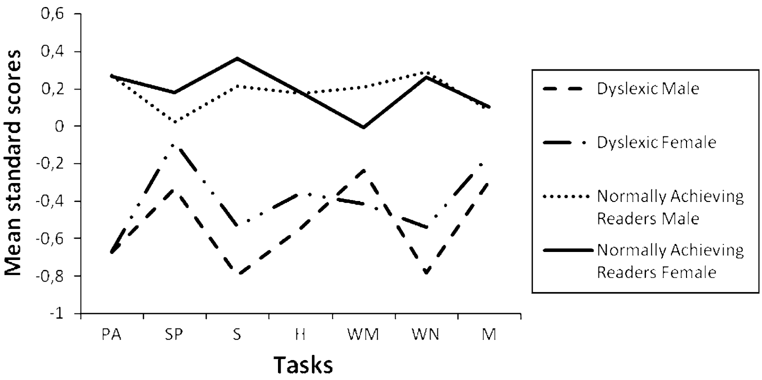

Fig. 2 Mean standard scores in cognitive processes as a function of Gender and Reading Level. *Note: PA* phonological awareness, *SP* speech perception, *S* Syntactic processing, *H* Homophone comprehension, *WM* working memory, *WN* word naming task accuracy, *M* morphological processing

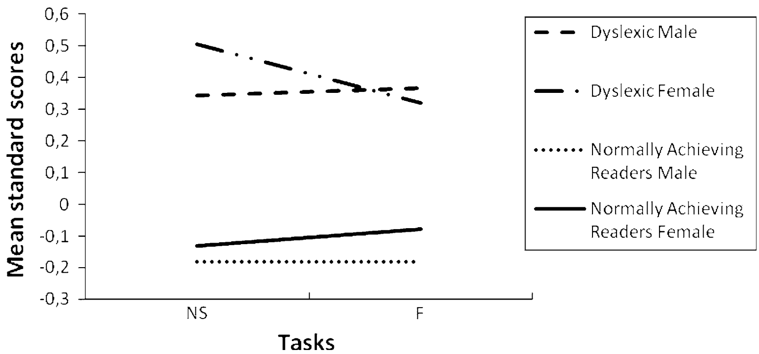

Fig. 3 Mean standard scores in cognitive processes as a function of Gender and Reading Level. *Note: NS* naming speed, *F* fluency

subsumed under a significant nationality × gender × reading level interaction. Test of simple main effect confirmed that there were differences between males and females, and between nationalities for normally achieving readers $F\,(1, 972) = 46.3$, $p < 0.001$ but not for dyslexic children, $F\,(1, 972) = 0.23$, $p = 0.630$.

Discussion

The present study had two aims. First, an analysis of gender-related differences in dyslexia was conducted focusing on a cross-national comparison of the prevalence of dyslexia in a transparent orthography. Second, in order to test the hypothesis about possible gender-related differences, an analysis of the profile of cognitive deficits in girls and boys with dyslexia was also conducted.

The controversy over whether boys are more likely than girls to have reading disabilities are unresolved (Berninger et al., 2008). In our across-countries samples there were 946 male and 659 female (ratio: 1.4:1). The sample identified with dyslexia was 163 males and 111 females (ratio: 1.4:1). This finding is very similar to results in research-defined samples, because the ratio of boys to girls is slightly above a one-to-one ration (Chan et al., 2007; Shaywitz et al., 1990; Wadsworth et al., 1992). Other population based studies have consistently reported that reading disabilities were more prevalent in boys than girls, even when race, attention, and activity levels were controlled (Flannery et al., 2000). However, their measure of reading disability was based on a single measure of real word reading and did not include a test of phonological decoding (pseudoword reading) which has been shown to be critical in diagnosing reading disability (e.g., Stanovich, 1986; Wagner & Torgesen, 1987). Using these criteria in the present study we found some differences with regard to the prevalence of dyslexia in the samples studied in both countries. The ratio of dyslexics across the countries in the total sample was 1.3:1, that is, four Guatemalan dyslexics to three Spanish dyslexic. So, the odds ratio indicated that dyslexics from Guatemala were 1.3 times more likely to be detected than Spanish dyslexics. One possible explanation of the finding of more dyslexics in Guatemala is that environmental variables can play important roles in the frequency and characterization of reading problems. Bravo-Valdivieso (2001) suggested that it is likely that the prevalence of children with reading disabilities in South American countries is greater than in the United States or in European countries because of factors like poor nutrition, cognitive-verbal development, and unsanitary conditions.

After we found that prevalence of dyslexia in boys and girls is not different across the countries, the question arises as to whether dyslexic boys show a pattern of cognitive deficits similar to that of dyslexic girls. Therefore, the second purpose of our study focused on the interaction between gender, nationality and dyslexia from an information-processing model. We did not find significant cross-national patterns of gender-related significant differences in literacy skills nor in reading-related cognitive abilities among children with dyslexia. Our dyslexic children present difficulties in the majority of cognitive domains measured in this study (i.e., phonological awareness, speech perception, syntactic processing, orthographical skills, working memory, naming, and morphological processing). Nevertheless, in a recent study with Spanish children, Bednarek, Saldaña, and García (2009) analyzed visual and phonological abilities in dyslexic boys and girls. No sex differences were found in phonological abilities, while in coherent motion perception male advantage was well pronounced, and the effect of sex was especially clear overall in the dyslexic group: only dyslexic girls appeared to be deficient in coherent motion perception. They suggested that these results may be an example of differentiation in neurobiological underpinnings of dyslexia in both sexes but they did not provide empirical evidence about structural brain differences in boys and girls with dyslexia.

Overall, our research is also consistent with previous research (e.g., Chan et al., 2007; Chiappe, Siegel, & Wade-Wooley, 2002; Share & Silva, 2003; Siegel & Smythe, 2005). For instance, Siegel and Smythe (2005) analyzed data from a large longitudinal study in North Vancouver (Canada), which included 984 children seen longitudinally from kindergarten until Grade 5. They only found gender-related differences in kindergarten and Grade 1, but these differences disappeared later. In addition, Share and Silva (2003) found that females with specific reading disabilities showed the same pattern of deficits as males with specific reading disabilities.

Most recently, Chan et al. (2007) investigated in Chinese children whether or not there were gender differences in reading-related cognitive abilities in the dyslexic sample. They considered the six cognitive domains for gender differences separately (i.e., naming speed, phonological awareness, phonological memory, orthographic knowledge, visual perception, and visual memory), and found a slightly higher prevalence of dyslexia in boys but this gender imbalance was not explained by gender differences in cognitive abilities.

Finally, our study has limitations because we did not control the comorbidity of writing and reading problems in our dyslexic sample. Berninger et al. (2008) have recently suggested that gender differences in the children and adults with dyslexia would be found in their mean level or writing skill development rather than reading skill development. They found that boys were not more impaired that girls on any of the reading measures (i.e., accuracy and rate of single real word and pseudoword reading), however, males were consistently more impaired than females in orthographic skills, which may be the source of gender differences in writing.

In conclusion, results obtained from the present study provide little or no evidence for gender-related differences in the prevalence of reading disabilities across different countries with a transparent orthography. However, there was an interaction between nationality and reading level. Therefore, environmental variables can play important roles in the frequency and characterization of reading problems but not related to gender differences. Finally, there were no significant or meaningful gender-related differences with regard to the profile of cognitive deficits in girls and boys with dyslexia, in spite of a slightly higher prevalence of dyslexia in boys.

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