

# Are Phonological Processes Separate from the Processes Underlying Naming Speed in a Shallow Orthography?

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## Abstract

**Introduction.** The present study examined the contributions of phonological decoding skills and rapid naming to the prediction of reading skills in Spanish-speaking children with dyslexia.

**Method.** Thirty-eight dyslexic readers with phonological decoding processing deficits (mean age 9;11) were assessed on reading speed, reading comprehension, word and pseudoword reading, orthographic choice, and Rapid Naming (RAN). Correlation and regression analyses were conducted to examine interrelationships among these variables in Spanish, a language with a transparent orthography.

**Results.** Supporting previous findings of the Double Deficit Hypothesis in transparent orthographies, a significant relationship was found among RAN measures, reading speed, and orthographic knowledge; and between phonological decoding skills and word reading accuracy. Both word reading accuracy and RAN tasks were associated with reading comprehension.

**Conclusions.** In the present study, the predictive capability of RAN-Numbers to orthographic knowledge and RAN-Letters to reading speed was the highest among all cognitive measures underlie reading. .

**Keywords:** Dyslexia, Reading, Spanish, RAN, Phonological skills.

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## Resumen

**Introducción.** El presente estudio examinó la contribución de las habilidades de decodificación fonológica y de denominación automatizada rápida a la predicción de la habilidad lectora en niños españoles con dislexia.

**Método.** Treinta y ocho lectores con dislexia y déficit en el procesamiento fonológico (edad media 9 años y 11 meses) fueron evaluados en velocidad lectora, comprensión lectora, lectura de palabras y pseudopalabras, ortografía, y denominación rápida. Se efectuaron análisis de correlación y regresión para examinar las interrelaciones entre estas variables en Español, una lengua con ortografía transparente.

**Resultados.** Como en estudios anteriores sobre la Hipótesis del Doble Déficit en ortografías transparentes, se encontró una relación significativa entre las medidas de denominación rápida, velocidad lectora y conocimiento ortográfico; y entre las habilidades de decodificación fonológicas y la precisión en la lectura de palabras. Tanto la precisión en la lectura como las medidas de denominación rápida correlacionaron con la comprensión lectora.

**Conclusiones.** En el presente estudio, la capacidad predictora de la denominación automatizada rápida de números al conocimiento ortográfico y de la denominación automatizada rápida de letras a la velocidad lectora fue la más alta de entre todas las medidas subyacentes a la lectura utilizadas. .

**Palabras Clave:** Dislexia, Lectura, Español, Habilidad Fonológica, Denominación Rápida

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## **Introduction**

Reading disability is one of the most common childhood disorders (Berninger, Abbott, Thomson & Raskind, 2001). Children with dyslexia have difficulty learning to read and spell in spite of adequate intelligence and educational opportunity and in the absence of any profound sensory or neurological impairment. Furthermore, no orthography appears immune to reading disorders. It is well documented that developmental reading disabilities are a problem with global dimensions (Katzir, Shaul, Breznitz & Wolf, 2004). Emerging data suggests that dyslexia is manifested in distinctively varied ways in different languages (e.g., incidence; proportion and severity of the various deficit types) (Katzir, Shaul, Breznitz, & Wolf, 2004; Landerl, Wimmer, & Frith, 1997) . However, most of what is known about the nature and origin of dyslexia comes from studies conducted in English-speaking countries. In fact, about two-thirds of all publications on the topic were conducted with English-speaking children (Ziegler et al., 2003). Nevertheless, behavioral cross-linguistic studies suggest that the nature and prevalence of dyslexia might differ between orthographies (Ziegler & Goswami, 2005). In addition, neuroimaging studies suggest contradictory findings regarding the universal basis of dyslexia (see Paulesu et al., 2001 vs. Siok et al., 2004).

The goal of this study is to add to the growing literature on the nature of reading challenges in children who are learning to read Spanish - a transparent orthography. While most cross-linguistic studies of reading have focused on differences in word level reading, this study will also look at connected-text reading. Specifically, it will focus on the cognitive and linguistic components that predict word reading speed and accuracy, reading comprehension, and orthographic knowledge.

## **Differences in learning to read across different alphabetic languages**

Disparate languages differ in their morphology, phonology, and orthography; and in the interrelationships among these linguistic components. Most striking are the differences in the rules for grapheme-phoneme correspondences between different alphabetic systems. An accumulating number of studies suggest that learning to read in English is more challenging, and possibly qualitatively different than, learning to read other European orthographies (Goswami, Zeigler, Dalton & Schneider, 2003). In English, an opaque orthography, the development of decoding skills is slower than in regular or transparent orthographies, where the correspondences between graphemes and phonemes are highly consistent. Therefore, children

learning to read in more transparent orthographies than English have fewer difficulties in decoding written words than English-speaking children (Cossu, Shankweiler, Liberman, Katz & Tola 1988; Frith, Wimmer & Landerl, 1998; Jiménez & Ramirez, 2002; Katz & Frost, 1992; Katzir, et al., 2004; Landerl, Wimmer & Frith, 1997; Spencer & Hanley, 2003; Wimmer & Goswami, 1994).

A European collaborative study across 13 countries showed that while only 40% of English-speaking children read correctly by the end of first grade, reading accuracy in most other European orthographies was close to ceiling by that time (see Seymour et al., 2003 for full report). Studies in German (Landerl & Wimmer, 2000) and Dutch (Yap & van der Leij, 1993) have suggested that the combination of a regular orthography and a synthetic phonics teaching method, most often used in countries with a transparent orthography, enables even dyslexic children to acquire adequate phonological decoding abilities. Goswami, Gombert, and de Barrera (1998) also found superior pseudoword reading in Spanish children relative to French and English children. In order to understand the nature of these vast differences in the rate of reading acquisition, researchers have examined the nature of lower level processes such as phonological awareness and rapid naming across different languages.

### **Phonological deficits across different languages**

Until recently, phonological processes were considered the primary source of dyslexia. Several studies in the past three decades have shown that many dyslexics have phonological processing deficits (Rack, Snowling & Olson, 1992; Snowling, 1995; Swan & Goswami, 1997). In other words, many English-speaking dyslexic children have difficulties with specifying and retrieving phonological representations. These children are typically characterized as having persistent difficulties with phonological processing tasks such as rhyming and pseudoword repetition, and with reading pseudowords as compared to sight words (Adams, 1990; Bradley & Bryant, 1983; Liberman & Shankweiler, 1979; Stanovich, 1988; Stanovich & Siegel, 1994; Torgesen, Warner, Rashotte, Burgess & Hecht, 1997; Vellutino et al., 1996; Wagner & Torgesen, 1987).

Studies in languages other than English have confirmed that phonological deficits are universal. For example, Spanish studies on reading disabilities have also found that phono-

logical skills, as assessed by tests of phonemic awareness or pseudoword decoding, are related to reading and spelling acquisition (Jímenez & Hernández-Valle, 2000; Jímenez & Ortiz, 1998; Rodrigo & Jímenez, 1999). However, the link between phonological deficits and phonological print-mediated decoding is less direct in transparent languages such as Spanish. That is, poor readers in Spanish often read words accurately after a short period of training, and their main reading problem is *slow* decoding for unusual or long words that are read fluently by average readers (Davies, Cuetos & Glez-Seijas, 2007; Grompone, 1975). These readers use the phonological route proficiently but at a slower rate. In the Spanish language, the number of syllabic structures is limited, and irregularities of phoneme-grapheme mapping can be resolved by taking into account the structure of the syllable where the graphemes appear in the word. For these reasons, word decoding does not pose a challenge in the Spanish language (Davies et al, 2007; Jímenez & Hernández-Valle, 2000; Rodrigo & Jímenez, 1999).

Because phonological decoding is easier to master in Spanish than in English, phonological dyslexics are harder to detect. Differences between good readers and the reading disabled become more apparent when pseudowords or words with low frequency are used. For this reason, pseudoword reading is the most commonly used task in Spanish to select dyslexic children characterized by difficulties in using the phonological route (Guzmán et al., 2004; Jímenez et al., 2003).

Given the early proficiency of children learning to read in transparent languages, and the lack of errors in word reading, we hypothesize that phonological decoding cannot be the only predictor of individual differences in word reading and reading comprehension in Spanish. While the phonological-core-deficit hypothesis of reading disability is also widely accepted in transparent orthographies, it is insufficient to capture the richness and heterogeneity of the different profiles of dyslexics, with the result that some children learning to read a transparent orthography often do not receive appropriate diagnosis, classification, and treatment (Katzir et al., 2004).

### **Naming speed deficits across different languages**

A deficit in the processes related to serial naming speed has been hypothesized as another possible source of reading difficulties (Wolf & Bowers, 1999). This alternative model,

known as the Double-Deficit Hypothesis (DDH), acknowledges that most children with dyslexia have phonological awareness deficits. However, some children, especially the most impaired ones, have an additional deficit in the processes underlying naming. Three decades of research demonstrate that the vast majority of children and adults with reading disabilities are slower than age-matched samples in rapid naming or naming-speed tasks, in which subjects must identify an array of familiar visual symbols presented serially, such as letters; numbers; colors; and simple objects (Denckla & Rudel, 1976; Semrud-Clikeman, Guy, Griffin & Hynd, 2000; Wolf & Bowers, 1999; Wolf, Bowers & Biddle, 2000; Zeffiro & Eden, 2000). Moreover, it has previously been found that difficulties in rapid naming, reading, and spelling persist into early adulthood in some dyslexic readers (Korhonen, 1995).

Following Bowers and Wolf's (1993) hypothesis that naming speed is a significant predictor of reading fluency in English-speaking children quite independently of phonological processing, there has been considerable interest in its role as a predictor of variation in reading abilities among children learning to read in transparent languages including Finnish (Korhonen, 1995), Spanish (Escribano, 2007; Jiménez et al., 2008; Novoa & Wolf, 1984), German (Frith et al., 1998; Landerl, 2001; Wimmer, Mayringer & Landerl, 2000), Italian (Di Filippo et al., 2005), and Dutch (van den Bos, 1998; Yap & van der Leij, 1993). Taken together, these studies' findings are broadly consistent with the view that rapid naming problems seem to be one of the main characteristics of dyslexic children learning to read in a transparent orthography.

### **Do phonological decoding and rapid naming contribute independently to variance in word and connected text reading tasks?**

Currently, there are two views regarding the underlying process by which rapid naming measures relate to reading. The first view considers naming speed as a phonological processing skill and attributes the relationship between naming speed and early reading to the phonological nature of the naming speed task (Share, 1995; Torgesen & Burgess, 1998; Vukovic & Siegel, 2006). Support for this view has been found in the moderate correlations between naming speed tasks and measures of phonological awareness, and in the finding that naming speed does not uniquely predict measures of orthographic awareness beyond the effects of phonological awareness (Torgesen et al., 1997). Studies supporting this view from transparent orthographies including Dutch (Patel, Snowling, & de Jong, 2004) and Spanish

(Guzmán et al., 2004) have found that phonemic awareness is a critical skill in learning to read in languages with shallow orthographies, and that rapid naming was not a significant predictor of word reading.

The Spanish study by Guzmán et al. (2004) tested the prediction capabilities of the phonological and double deficit hypotheses by examining word reading and naming speed among reading disabled fourth graders. The participants were selected according to their phonological processing deficit, and compared to both chronological age-matched average readers, and reading age-matched second graders. Reading disabled children were slower in the RAN tasks than their age matched controls, but similar to the reading age group of second graders. Thus, the authors suggested that the naming speed deficit of the reading disabled children was caused by their phonological processing deficit.

The second view regarding the relationship between rapid naming and word reading stresses that rapid naming and phonological decoding represent independent processes. Support for this view was found at the connected text and reading comprehension levels, where each component contributed independently to variance in the performance of children with and without dyslexia (Katzir et al., in press). In addition, it has been found that children with the most severe reading problems are those with low RAN scores, rather than those with low scores on phonological decoding tasks). Further support for this view comes from studies in German (Frith et al., 1998; Landerl, 2001; Wimmer et al., 2000), Dutch (de Jong & van der Leij, 2003; van den Bos, 1998; Yap & van der Leij, 1993), and Spanish (Escribano, 2007; Jiménez et al., 2008), three languages with a more transparent or regular orthography than English, which found naming speed to be a more robust predictor of reading performance than phonological awareness and phonological decoding measures.

In summary, whereas it seems logical that phonological skills are necessary for decoding, the relation between rapid naming and reading remains unknown, especially for non-English languages. The connection between slow naming and poor reading is much less obvious than the reason inadequate phonemic awareness is associated with poor decoding. These behavioral predictors of reading share some variance, but it is hypothesized that, “their major impact is respectively on the ability to sound out novel words or phonological decoding, and on the ease of building up orthographic knowledge from print exposure” (Bowers & Wolf, 1993).



It has been suggested that RAN measures automaticity in linking visual symbols with pronunciations, which affects reading fluency (Bowers & Wolf, 1993; Katzir et al., 2006; Manis, Seidenberg & Doi, 1999; Wolf 1997). By this reasoning, processes responsible for the slow recognition of multiple letters in common orthographic patterns adversely affect visual representations to form orthographic codes of words. Although the proponents of this view acknowledge that naming speed tasks share some variance associated with phonological awareness and phonological decoding tasks, they argue that there seems to be a strong relationship between naming speed and word and text fluency, and between phonological awareness and word attack (Bowers & Newby-Clark, 2002).

At the connected-text reading level, dissociation between accuracy and connected-text fluency has been suggested in several studies. This is especially true for studies on other Latin languages in which the focus was on predictors of word-level reading rather than connected-text reading and comprehension (see Zeigler et al., 2003 for review of cross-linguistic studies). Several studies have shown that naming speed, not phonological awareness, can predict gains in fluency due to a set amount of practice with individual words or with repeated reading of a specific text in a single session (Bowers, 1993; Bowers & Kennedy, 1993; Young, 1997). Along the same line, work by Torgesen, Rashotte, Alexander, Alexander, and MacPhee (2003) showed that training in phonemic awareness affects accuracy of later decoding, but has a much lower effect upon fluency. Additional studies claimed that naming speed tasks, such as the ability to rapidly name letters, have consistently predicted reading performance beyond what was accounted for by phonological awareness skills (Manis, Doi & Bhadha, 2000; Wolf & Bowers, 1999; Wolf et al., 2002).

Consequently, the goals of the present study were to determine the relationships among cognitive variables shown to underlie reading in a transparent orthography and compare the results to those on similar tasks in English, to examine the contributions of phonological decoding skills and rapid naming to the prediction of reading skills in Spanish, and to provide practitioners and researchers with reading assessment and intervention recommendations.

Based on issues raised in the current literature on the DDH, the specific questions this study aims to answer are:

- 1) Does naming speed appear to be strongly related to specific aspects of reading performance (i.e., reading speed and orthographic knowledge), and are phonological decoding skills related to word attack (accuracy for real words) in Spanish-speaking children at risk for reading difficulties? Are naming speed and phonological decoding skills correlated with each other?
  
- 2) What proportion of the variance in word reading accuracy, reading comprehension, reading speed, and orthographic knowledge is uniquely attributable to phonological decoding skills and/or naming speed ability?

It might be expected that the results would indicate a unique contribution of phonological decoding skills to word reading accuracy after controlling for naming speed, and a unique contribution of naming speed to orthographic skills and reading speed after controlling for phonological decoding skills. It is expected that reading comprehension will be predicted by both behavioral measures.

## **Method**

### *Participants*

Subjects for this study were recruited from a number of sources, including referrals from pediatricians, speech therapists, and educators.

As stated earlier, phonological decoding is easier in Spanish than in English, and phonological dyslexics are harder to detect. Pseudoword reading is the task used in Spanish to select dyslexic children characterized by difficulties in using the phonological route. In accordance with this criterion, the initial selection of subjects was made based on pseudoword reading performance. In order to participate in the study as a dyslexic reader, a child had to score at or below the 30<sup>th</sup> percentile on the 'Evaluación de los procesos lectores' (PROLEC) (Cuetos, Rodríguez & Ruano, 1996) or PROLEC-SE (Secondary Education) (Ramos & Cuetos, 1999) pseudoword subtest. PROLEC is intended for children in first to fourth grades, while PROLEC-SE is geared toward children in the fifth to tenth grades. A total of 38 boys were recruited. The sample was limited to boys because more boys are found among poor

readers than girls. The participants ranged in age from 8;0 to 13;6, with a mean age of 9;11. Participants spoke Spanish as their mother tongue and were not included in the sample if they evidenced severe emotional problems, mental retardation, uncorrected vision problems, hearing loss, or acquired neurological disorders. In addition, participants were required to score above 80 on the WISC-R scale. All families gave informed consent allowing their children to participate (see Table 1).

**Table 1. Participants Age, IQ, and Scores on Reading Outcome Measures (n = 38)**

	<b>M</b>	<b>Median</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>
<b>Age</b> (years;months)	9;11	9;8	1.68	8	13;6
<b>IQ (WISC-R)</b>	101	103.50	11.34	80	124
<b>Reading Speed</b>	67.53	59	33.10	11	166
(words per minute)					
<b>Reading Comprehension*</b>	58.81	60	25.45	0	100
<b>Word Reading*</b>	93.39	96	7.42	75	100
<b>Pseudoword Reading*</b>	74.97	80	13.63	35	93
<b>Orthographic Choice*</b>	62.89	60	17.53	20	100
<b>RAN objects</b>	57.16	60	13.53	30	85
(total time in seconds)					
<b>RAN colors</b>	55.13	56.50	11.61	31	77
(total time in seconds)					
<b>RAN numbers</b>	40.24	37.50	12.94	21	68
(total time in seconds)					
<b>RAN letters</b>	37.66	38.50	8.87	20	56
(total time in seconds)					

\* percentage of correct answers

### *General Procedures*

The children were tested individually by a speech therapist and a psychologist in two sessions that lasted about 45 minutes each. Several tasks were administered, including assessments of reading, phonological decoding, orthography, and naming speed.

### *Instruments*

*Reading speed.* Two texts of different difficulty levels were selected from the PROLEC (Primary Level) and PROLEC-SE (Secondary Level). Children were asked to read the texts aloud. A stopwatch was used to record overall reading time, in minutes, on each text. These times were averaged to yield a single words-per-minute measure for reading speed. This words-per-minute measure is reported.

*Reading comprehension.* The comprehension subtests of the PROLEC and PROLEC-SE were used as measures of reading comprehension.

The PROLEC reading comprehension subtest includes four texts of different difficulty levels with four comprehension questions at the end of each text. Split-half reliability from norms for the PROLEC reading comprehension subtest was .92. The percentage of correct answers is reported.

The PROLEC-SE reading comprehension subtest includes two texts with 10 comprehension questions at the end of each text. Split-half reliability from norms for the PROLEC-SE reading comprehension subtest was .85. The percentage of correct answers is reported.

Reading of the texts was done aloud prior to completion of the questions.

*Word reading.* Ability to use phonics skills to decode words was assessed using a word reading subtest derived from the PROLEC and PROLEC-SE. The subtest from the PROLEC required the child to read 30 words aloud, while the subtest from the PROLEC-SE required 40 words aloud. Neither subtest placed a time limitation on the task. The correct number of words read was converted to a percentile score, which is reported.

*Pseudoword reading.* Ability to use phonics skills to decode pseudowords was assessed using a pseudoword reading subtest derived from the PROLEC and PROLEC-SE. The subtest from the PROLEC required the child to read 30 pseudowords aloud, while the subtest from the PROLEC-SE required 40 pseudowords aloud. Neither subtest placed a time limitation on the task. The correct number of pseudowords read was converted to a percentile score, which is reported.

*Orthographic choice.* The orthography rules subtest of the 'Batería de Evaluación de la Lectura' (BEL) (López-Higes, Mayoral & Villoria, 2002) was used as a measure of orthographic recognition. BEL is a measure of orthographic coding that requires a choice to be made between a word and two phonologically identical pseudohomophonic pseudowords (*e.g. veber, beber, beber*) (English: drink). Each student was presented with one sheet (Level I or Level II) containing a total of 10 triads of printed stimuli, that although phonologically similar, were orthographically dissimilar. This task requires the subject to recognize the correct orthographic pattern for the word independently of its phonology. Participants circled the right word to designate the correct orthographic pattern. In this task, use of phonics skill to decode sound-alike targets does not improve selection accuracy. Instead, better word-specific orthographic knowledge should affect the number of correct choices. Split-half reliability

from norms was 0.77 for the Level I sheet, and 0.60 for the Level II sheet. The correct number of choices was converted to a percentile score, which is reported.

*Rapid Automated Naming (RAN).* Rapid naming was assessed through the administration of Denckla and Rudel's (1974) Rapid Automated Naming test for objects, colors, numbers, and letters (RAN-Objects, RAN-Colors, RAN-Numbers, and RAN-Letters). Each of the four tasks consists of an array of five items. Ten lines are present on each page with the five items presented in random order in each line. Hence, one page contains 50 simple object drawings, another color patches, another single digits, and another single letters. Before beginning each task, participants were asked to provide the name of each item in the array in order to assess familiarity with the presented stimuli. Once familiarity was assessed, participants were presented with the page containing the matrix of symbols and asked to name each item from left to right as quickly and as accurately as possible. The number of errors was recorded and a stopwatch was used to record the overall time in seconds it took for the child to name each list. Test-retest reliability reported from norms was .84 for RAN-Objects, .93 for RAN-Colors, .90 for RAN-Numbers, and .92 for RAN-Letters, at the middle school level. Total time in seconds is reported.

## Results

*Question 1:* What is the relationship among naming speed and phonological decoding skills to specific aspects of reading performance (i.e., word reading accuracy, reading comprehension, reading speed, and orthographic knowledge) in Spanish speaking children at risk for reading difficulties?

### *Pearson's correlation analyses*

Table 2 illustrates the correlation coefficient estimates for the reading measures. Inspection of the correlation matrix revealed moderate to high correlations among most reading measures. The four RAN measures - RAN-Objects, RAN-Colors, RAN-Numbers, and RAN-Letters - correlated highly with each other ( $r = .68$  to  $.85$ ), with reading speed ( $r = -.44$  to  $-.57$ ), and with orthographic choice ( $r = -.37$  to  $-.55$ ). The highest correlation among the RAN measures was between RAN-Numbers and RAN-Letters ( $r = .85$ ). A significant positive correlation was also found between the RAN measures and reading comprehension ( $r = .35$  to

.47). The RAN measures did not correlate with either word or pseudoword reading. However, word reading was significantly correlated with pseudoword reading ( $r = .45$ ) and reading comprehension ( $r = .40$ ).

**Table 2. Correlations Between Reading Measures (n = 38)**

	1	2	3	4	5	6	7	8	9
<b>1. Reading Speed</b> (words per minute)									
<b>2. Comprehension<sup>a</sup></b>	0.22								
<b>3. Word Reading<sup>a</sup></b>	0.17	0.40*							
<b>4. Pseudoword Reading<sup>a</sup></b>	0.32	0.09	0.45**						
<b>5. Orthography<sup>a</sup></b>	0.58**	0.17	0.14	0.03					
<b>6. RAN objects</b> (total time in seconds)	-0.44**	0.37*	0.11	-0.10	-0.37**				
<b>7. RAN colors</b> (total time in seconds)	-0.51**	0.47**	0.16	-0.06	-0.42**	0.78**			
<b>8. RAN numbers</b> (total time in seconds)	-0.52**	0.38*	0.08	-0.05	-0.55**	0.68**	0.72**		
<b>9. RAN letters</b> (total time in seconds)	-0.57**	0.35*	0.12	-0.12	-0.46**	0.72**	0.76**	0.85**	
<b>10. Age</b> (in months)	0.13	-0.27	-0.29	-0.29	0.07	-0.32	-0.30	-0.23	0.15

Key: \*  $p < 0.05$ ; \*\*  $p < 0.01$

<sup>a</sup> percentage of correct answers

*Question 2: Can phonological decoding skills and naming speed concurrently predict reading skills in Spanish-speaking children with reading difficulties?*

### *Regression analyses*

Multiple stepwise regression models were conducted in order to determine whether variables such as pseudoword and word reading accuracy, and RAN, accounted for independent variance in word reading accuracy, reading comprehension, reading speed, and orthographic choice.

Four linear hierarchical multiple regression analyses were conducted. The results are shown in Tables 3, 4, 5, and 6.

The first model (see Table 3) examined word reading accuracy as the dependent variable and pseudoword reading, RAN-Letters and RAN-Colors as predictors. Pseudoword reading accuracy uniquely explained a significant portion of variance (20%). The RAN measures did not contribute any additional variance to the model.

The second model shows (see Table 4) reading comprehension as the dependent variable and word reading accuracy, RAN-Colors, and RAN-Numbers as predictors. The complete model accounted for 32% of the variance. Change in  $R^2$  associated with the entry of each variable are provided in Table 4. RAN-Colors uniquely explained a significant portion of

variance (22%), and word reading accuracy explained 10%. RAN-Numbers did not contribute any additional variance to the model.

The third model shows (see Table 5) reading speed as the dependent variable and RAN-Letters, word reading accuracy, and pseudoword reading accuracy as predictors. In this model, RAN-Letters uniquely explained a significant portion of variance in reading speed (32%). Word and pseudoword reading accuracy did not contribute any additional variance to the model.

The last model shows (see Table 6) orthographic choice as the dependent variable and RAN-Letters, RAN-Numbers, and word reading accuracy as predictors. In this model, RAN-Numbers uniquely explained a significant portion of variance in orthographic choice (30%). RAN-Letters and word reading accuracy did not contribute any additional variance to the model.

**Table 3. Multiple regressions results: Unique variance in Word reading accuracy, controlling for Pseudoword reading, RAN-Letters, and RAN-Colors (n = 38)**

Step	Variable	R	R <sup>2</sup> change	F change
1.	Pseudoword reading	0.44	0.20	9.10*

Key: \*\*p<.001 \*p<.05

(RAN-Letters and RAN-Colors were excluded from the model)

**Table 4. Multiple regressions results: Unique variance in Reading comprehension, controlling for Word reading accuracy, RAN-Colors, and RAN-Numbers (n = 38)**

Step	Variable	R	R <sup>2</sup> change	F change
1.	RAN-Colors	0.47	0.22	10.45**
2.	Word reading accuracy	0.57	0.10	5.47*

Key: \*\*p<.01; \*p<.05

(RAN-Numbers was excluded from the model)

**Table 5. Multiple regressions results: Unique variance in Reading speed, controlling for RAN-Letters, Word reading and Pseudoword reading (n = 38)**

Step	Variable	R	R <sup>2</sup> change	F change
1.	RAN-letters	0.57	0.32	17.30**

Key: \*\*p<.01; \*p<.05

(Word and Pseudoword reading were excluded from the model)

**Table 6. Multiple regressions results: Unique variance in Orthographic choice, controlling for RAN-Letters, RAN-Numbers, and Word reading (n = 38)**

Step	Variable	R	R <sup>2</sup> change	F change
1.	RAN-Numbers	0.54	0.30	15.47**

Key: \*\*p<.001 \*p<.05

(Word reading and RAN-Letters were excluded from the model)

## Discussion

The main objective of the present study was to examine the relationship between phonological decoding processes and naming speed in Spanish, a transparent orthography. The study also examined the ability of these processes to concurrently predict reading skills in Spanish-speaking children with reading difficulties.

The importance of studying naming speed in languages with greater regularity than English is that they provide a means of examining the influence of naming speed and phonological decoding skills when phonological demands are decreased by a more transparent orthography than that of English.

*What is the relationship among phonological decoding skills, processes underlying naming speed, and reading among Spanish speakers?*

The findings of this study confirm that naming speed and phonological decoding skills are separate entities in Spanish and lend support to the DDH (Wolf & Bowers, 1999).

It has been argued that moderate correlations between phonological decoding tasks and naming speed tasks may indicate that the two tasks actually tap into the same processes (Vukovic & Siegel, 2006). However, several studies among English-speaking children found only modest correlations among these tasks. This was especially true for samples with severe



reading difficulties (Katzir et al., in press; Schatschneider, Carlson, Francis, Foorman & Fletcher, 2002). In our sample of Spanish-speaking children with reading difficulties, the RAN measures did not correlate with word reading accuracy or with pseudoword reading. Similar results were found in a study done in Italian, which is also a transparent orthography Italian (Di Filippo et al., 2005). These consistent findings from regular orthographies strengthen the claim that the contribution of RAN to reading acquisition is independent from the well-established effects of phonological decoding abilities.

In addition, phonological decoding skills and rapid naming exhibited a differential pattern of correlation with other reading skills. As predicted by the DDH in other transparent orthographies, significant relationships were found among RAN measures, reading speed, and orthographic knowledge (Katzir et al., 2006). Furthermore, a significant relationship was found between word reading accuracy and pseudoword reading. Also as predicted, word reading accuracy and the RAN-tasks were associated with reading comprehension.

#### *RAN as the significant predictor of reading in Spanish*

Regression analyses were used to further study these relationships. Results from several studies attest to the fact that phonological processes and naming speed contribute both unique and shared variance to measures of reading among different samples (Katzir et al., 2006). The results of the present study support previous findings that phonological processing skills are crucial for the development of decoding skills. Also, word reading accuracy was predicted by pseudoword reading, and the predictive capability of RAN-Numbers to orthographic knowledge and RAN-Letters to reading speed was the highest above all reading measures. Furthermore, there is much support for a relationship between orthographic skills and rapid naming. Several studies have shown that rapid naming is especially involved in the acquisition of orthographic knowledge (e.g., Manis et al., 2000; Sunseth & Bowers, 1997; Torgesen et al., 1997), and that children who score low on RAN tasks have problems extracting the regularities of frequent and common words.

The significant relationship among the RAN tasks, orthographic knowledge, and reading speed in our sample suggests, as Bowers and Wolf (1993) stated, that rapid naming is a fluency related process, particularly with respect to connected text, and is implicated with failure in learning to recognize words quickly.

In light of the unique contributions of the RAN tasks to reading speed and orthographic knowledge, and the unique contribution of pseudoword reading to word reading accuracy, we can conclude that whatever processes rapid naming taps, it cannot be subsumed under phonological processing tasks. Based on the results of the present study, it seems most accurate to conceptualize naming speed and phonological decoding skills as assessing separate abilities, rather than as assessing one general phonological ability.

Although the results of the present study lend some support to RAN as a measure related to the acquisition of orthographic knowledge and reading speed, the causal status of these relationships was not tested.

RAN-Letters and word reading accuracy contributed a significant proportion of the variance in reading comprehension in our study. The relatively high word reading accuracy and reading comprehension scores of this sample were quite surprising given the sample's severe reading difficulties, although the high level of reading accuracy is consistent with the findings reported by other studies of reading in Spanish (Davies et al., 2007; Jiménez & Hernández-Valle, 2000; Rodrigo & Jiménez, 1999). The positive correlation between the RAN-tasks and reading comprehension was unexpected as well.

In recent years, researchers have put an emphasis on developing word reading fluency to improve reading comprehension among struggling readers (Perfetti, 1999). According to Perfetti's theory, if word reading demands too much attention, the reader cannot direct his or her conscious attention to comprehending the text. Although the participants of the present study were quite impaired in rate, their comprehension skills were not severely affected. This could be explained by the compensatory-encoding theory (Walczyk & Griffith-Ross, 2007), which describes how readers with weak skills can comprehend by adjusting their reading method. The theory states that even when a text challenges comprehension, readers can take actions to improve reading performance, such as strategically slowing down reading rate or pausing. This might be the case for a high percentage of participants in our study.

Finally, another goal of the present study was to provide practitioners and researchers with reading assessment and intervention recommendations. With respect to this, several conclusions can be drawn accordingly.

First, the relationship among RAN tasks, orthographic knowledge, and reading speed emphasizes the need to include a number of different assessment measures and appropriate interventions for reading difficulties. This study's findings suggest that the consequences of developmental dyslexia include, but are not confined to, a phonological decoding deficit. Therefore, assessments and interventions based exclusively on word reading and decoding should not be the only approaches to reading disabilities in Spanish-speaking countries.

Second, as the results of the present study show, Spanish-speaking children usually have more problems related to reading speed and orthographic knowledge than to word reading accuracy. Their main reading problem is slow, laborious decoding of words when task demands increase. Thus, reading speed remains a core symptom of reading impairment. In this respect, our findings are consistent with those yielded by other studies in Spanish (Davies et al., 2007; Grompone, 1975) and in other transparent orthographies (Tressoldi, Stella & Fagella, 2001; Wimmer, 1993). Reading rate deficiencies are frequently missed on assessments, and a slower reading rate, as evident in many children with reading difficulties in Spain, presents a severe challenge as school related tasks increase in quantity and difficulty.

Third, some children may not be identified as having reading difficulties in the early grades, as was the case for some participants in the present study. However, as they face increasingly complex text in later grades, their rate inefficiencies may prevent them from keeping pace with the amount of required reading, and difficulties in finishing timed tests and exams may arise.

The results of the present study suggest considering (a) the rapid serial naming test as a useful and simple measure of some processes that are very important to reading in Spanish, such as orthography and reading speed, and (b) the importance of developing fluency-based intervention programs in Spanish, which are currently lacking. A reading intervention program aimed at improving accuracy and automaticity in the components and subskills underlying reading, fluency in word identification and connected text, and reading comprehension strategies would be of great interest.

As the sample studied was small, future research with a larger sample is needed before grand generalizations can be made from the results of the present study. In addition, examin-

ing the brain activation patterns of Spanish-speaking children conducting various reading and reading related tasks, such as the ones described in this study, will help underpin what role these processes play in reading a transparent language.

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