

This article was downloaded by: [Radboud University Nijmegen]

On: 4 January 2011

Access details: Access Details: [subscription number 907172236]

Publisher Psychology Press

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



## International Journal of Psychology

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713659663>

### Visual rapid naming and phonological abilities: Different subtypes in dyslexic children

Susana Araújo<sup>a</sup>; Andreia Pacheco<sup>a</sup>; Luís Faísca<sup>a</sup>; Karl Magnus Petersson<sup>b</sup>; Alexandra Reis<sup>c</sup>

<sup>a</sup> Universidade do Algarve, Faro, Portugal <sup>b</sup> Universidade do Algarve, Nijmegen, The Netherlands <sup>c</sup> Universidade do Algarve, Faro, Portugal, Karolinska Institutet, Stockholm, Sweden

First published on: 01 September 2010

**To cite this Article** Araújo, Susana , Pacheco, Andreia , Faísca, Luís , Petersson, Karl Magnus and Reis, Alexandra(2010) 'Visual rapid naming and phonological abilities: Different subtypes in dyslexic children', International Journal of Psychology, 45: 6, 443 — 452, First published on: 01 September 2010 (iFirst)

**To link to this Article:** DOI: 10.1080/00207594.2010.499949

**URL:** <http://dx.doi.org/10.1080/00207594.2010.499949>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

# Visual rapid naming and phonological abilities: Different subtypes in dyslexic children

Susana Araújo, Andreia Pacheco, and Luís Faisca

*Universidade do Algarve, Faro, Portugal*

Karl Magnus Petersson

*Universidade do Algarve, Faro, Portugal, Karolinska Institutet, Stockholm, Sweden,  
Max-Planck-Institute for Psycholinguistics, Nijmegen, and Radboud University,  
Nijmegen, The Netherlands*

Alexandra Reis

*Universidade do Algarve, Faro, Portugal, Karolinska Institutet, Stockholm, Sweden*

One implication of the double-deficit hypothesis for dyslexia is that there should be subtypes of dyslexic readers that exhibit rapid naming deficits with or without concomitant phonological processing problems. In the current study, we investigated the validity of this hypothesis for Portuguese orthography, which is more consistent than English orthography, by exploring different cognitive profiles in a sample of dyslexic children. In particular, we were interested in identifying readers characterized by a pure rapid automatized naming deficit. We also examined whether rapid naming and phonological awareness independently account for individual differences in reading performance. We characterized the performance of dyslexic readers and a control group of normal readers matched for age on reading, visual rapid naming and phonological processing tasks. Our results suggest that there is a subgroup of dyslexic readers with intact phonological processing capacity (in terms of both accuracy and speed measures) but poor rapid naming skills. We also provide evidence for an independent association between rapid naming and reading competence in the dyslexic sample, when the effect of phonological skills was controlled. Altogether, the results are more consistent with the view that rapid naming problems in dyslexia represent a second core deficit rather than an exclusive phonological explanation for the rapid naming deficits. Furthermore, additional non-phonological processes, which subserve rapid naming performance, contribute independently to reading development.

**Keywords:** Dyslexia; Double deficit; Phonology; Rapid naming.

Une implication de l'hypothèse du double déficit pour la dyslexie est qu'il devrait y avoir des sous-types de lecteurs dyslexiques qui montrent des déficits de dénomination rapide avec ou sans problèmes concomitants de traitement phonologique. Dans la présente étude, nous avons examiné la validité de cette hypothèse pour l'orthographe portugaise, laquelle est plus cohérente que l'orthographe anglaise, en explorant différents profils cognitifs chez un échantillon d'enfants dyslexiques. Nous étions plus particulièrement intéressés à identifier les lecteurs caractérisés par un déficit pur de dénomination rapide automatisée. Nous avons également examiné si la dénomination rapide et la conscience phonologique expliquent indépendamment les différences individuelles dans la performance à la lecture. Nous avons caractérisé la performance des lecteurs dyslexiques et d'un groupe contrôle de lecteurs normaux jumelés selon l'âge de lecture, la dénomination visuelle rapide et les tâches de traitement phonologique. Nos résultats suggèrent qu'il y a un sous-groupe de lecteurs dyslexiques ayant une capacité de traitement phonologique intacte (à la fois en regard des mesures d'exactitude et de rapidité), mais

Correspondence should be addressed to Alexandra Reis, Departamento de Psicologia, Faculdade de Ciências Humanas e Sociais, Campus de Gambelas, Universidade do Algarve, 8005-139 Faro, Portugal. (E-mail: aireis@ualg.pt).

This work was supported by grants SFRH/BD/27337/2006, SFRH/BD/28488/2006, PTDC/PSI/64920/2006, and IBB/CBME, LA, FEDER/POCI 2010 from Fundação para a Ciência e Tecnologia. We thank Heinz Wimmer and Rauno Parrila for their valuable comments.

ayant de pauvres habiletés de dénomination rapide. Nous avons également constaté une association indépendante entre la dénomination rapide et la compétence en lecture dans l'échantillon dyslexique, lorsque l'effet des habiletés phonologiques était contrôlé. En somme, les résultats sont plus compatibles avec le point de vue que les problèmes de dénomination rapide en dyslexie représentent un second noyau de déficit plutôt qu'une explication phonologique exclusive pour les déficits de dénomination rapide. De plus, les traitements non-phonologiques additionnels, lesquels favorisent la performance de dénomination rapide, contribuent indépendamment au développement de la lecture.

Una de las consecuencias de la hipótesis del déficit doble de la dislexia es la existencia de subtipos de lectores disléxicos que presentan problemas para el nombramiento rápido sin o con las concomitantes dificultades en el procesamiento fonológico. En este estudio se investigó la validez de esta hipótesis en relación a la ortografía portuguesa, la cuál es más consistente que la ortografía inglesa, a través de la exploración de diferentes perfiles cognitivos en una muestra de niños con dislexia. En particular estábamos interesados en la identificación de lectores caracterizados por un déficit puro en el nombramiento automático rápido. También se examinó si es que el nombramiento rápido y la conciencia fonológica explicaban independientemente las diferencias individuales en el rendimiento al leer. Se describió el rendimiento de lectores disléxicos y de un grupo control de lectores normales aparejados en la edad respecto de la lectura, del nombramiento visual rápido y de tareas de procesamiento fonológico. Los resultados sugieren que existe un subgrupo de lectores disléxicos con una capacidad de procesamiento fonológico intacto (ambos en términos de medidas de exactitud y rapidez) pero con pobres habilidades de nombramiento rápido. Además se presentó evidencia de una asociación independiente entre el nombramiento rápido y la competencia de lectura en la muestra disléxica, cuando se controló el efecto de las habilidades fonológicas. En conjunto estos resultados son consistentes con el postulado de que los problemas de nombramiento rápido en la dislexia representan una segunda limitación central, en lugar de una explicación fonológica exclusiva del déficit del nombramiento rápido. Por otro lado los procesos adicionales no fonológicos, los cuáles promueven el rendimiento del nombramiento rápido, contribuyen independientemente al desarrollo de la lectura.

Previous studies have shown that a majority of dyslexic subjects have persistent rapid naming problems in addition to their reading deficits. These rapid naming deficits have been extensively addressed using the rapid automatized naming (RAN) paradigm, developed by Denckla and Rudel (1976), in which subjects are asked to name, as quickly as possible, (highly) familiar visual stimuli. Although some studies suggest that alphanumeric (letters and digits) RAN tasks are more strongly related to reading, there is also evidence that performance on non-alphabetic (such as object and color) RAN tasks can be a good predictor of reading skills (Ackerman & Dykman, 1993; Denckla & Cutting, 1999; Fawcett & Nicolson, 1994; Lervåg & Hulme, 2009). Currently, the two main hypotheses concerning the nature of dyslexics' naming problems either view these as resulting from a selective phonological deficit (Clarke, Hulme, & Snowling, 2005; Faust & Sharfstein-Friedman, 2003; Swan & Goswami, 1997; Truman & Hennessey, 2006) or, alternatively, claim that rapid naming problems represent a second independent deficit of dyslexia (Bowers & Wolf, 1993; Wolf & Bowers, 1999; Wolf et al., 2002).

The double-deficit hypothesis emphasizes the multicomponent nature of dyslexia and suggests that the phonological deficit and the underlying

cause of the rapid naming deficits are two independent sources of reading failure. This results in three major types of impaired readers: two subtypes characterized by the presence of a single deficit at the level of the phonological processing or related to rapid naming, and a third subtype defined by the co-occurrence of both deficits (Wolf & Bowers, 1999; Wolf et al., 2002). Wolf and colleagues argued that the existence of impaired readers with average phonological skills and simultaneous naming difficulties makes it unlikely that rapid naming performance can be reduced to a purely phonological deficit. Instead, they posit an additional non-phonological deficit that accounts for rapid naming and reading impairment in dyslexia (Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000). Consistent with this, a number of studies have managed to identify the predicted subtypes (Kirby, Parrila, & Pfeiffer, 2003; Manis, Doi, & Bhadha, 2000; Papadopoulos, Georgiou, & Kendeou, 2009). However, others have failed to find dyslexic children who exhibit impaired naming performance without affected phonological skills (Badian, 1997; Vaessen, Gerretsen, & Blomert, 2009). As noted in a review by Vukovic and Siegel (2006), the empirical evidence with a bearing on the double-deficit hypothesis has so far not been consistent.

Important insights into the double-deficit hypothesis, and particularly into the independent role of rapid naming in predicting individual variability in reading, have been provided by multiple regression studies. The contribution of the causal correlates of rapid naming skills are less robust than the well-demonstrated role of phonological awareness skills, but overall a large number of studies agree on the importance of rapid naming in predicting reading ability beyond the influence of phonological factors (for a review, see Kirby, Roth, Desrochers, & Lai, 2008). This literature is, however, complicated by the fact that the reported findings might depend on the consistency of the orthographic system in which the studies were conducted. For example, convincing evidence shows that phonological awareness is the most important predictor of reading development in English (e.g., Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). However, recent cross-language studies with consistent orthographies have suggested that consistency rapidly promotes sufficiently high levels of phonological awareness in most individuals. This reduces the relative importance of phonological factors and increases the relative importance of the causal correlates of rapid naming in reading development, particularly in reading fluency (e.g., Landerl & Wimmer, 2000). In consistent orthographies, reading accuracy reaches a ceiling early and reading fluency constitutes the main problem for individuals with reading difficulties. A recent longitudinal study carried out by Landerl and Wimmer (2008) with German children from first to eighth grade provides support for this view. The authors observed that even poor readers mastered phonological decoding at the end of first grade and, therefore, phonological measures ceased to be significant predictors after this grade in that study. In addition, rapid naming performance was a good predictor of reading fluency at all measurement points. Similarly, in a study by Kirby and colleagues (2003) in an English-speaking sample, the authors argued that the declining predictive value of phonological awareness with grade level reflects a strategy shift from a reliance on phonetic/phonological to orthographic cues as children advance in reading development, rendering phonological competence less relevant to reading success.

These findings suggest that an exclusively phonological theory might not be sufficient to explain poor reading development or the poor rapid naming skills in poor readers. If rapid naming is a consequence of phonological processing competence, then it seems difficult to explain

why the predictive value of phonological awareness for reading development drops whereas rapid naming performance becomes more important with developmental time. Instead, these results suggest that at least some of the underlying causes of rapid naming difficulties are independent of phonological factors.

Equally controversial is the question of which cognitive processes mediate the relationship between rapid naming and reading competence, which in some studies show the most robust relationship among the poorest readers (Johnston & Kirby, 2006; Kirby et al., 2008). A number of authors have argued that the predictive power of rapid naming is because it is a measure of phonological code access and thus not independent of phonological factors (Chiappe, Stringer, Siegel, & Stanovich, 2002; Schatschneider, Carlson, Francis, Foorman, & Fletcher, 2002). Others, however, have claimed that non-phonological factors are responsible for the relationship between rapid naming and reading (Wolf & Bowers, 1999; Wolf et al., 2000). The latter position is consistent with the main assumption of the double-deficit hypothesis: rapid naming skills contribute independently in explaining individual reading differences (i.e., when phonological factors are factored out; Escibano, 2007; Manis et al., 2000).

Several explanations have been advanced to explain these non-phonological mechanisms. For example, it has been argued that slow single-letter recognition prevents the formation of between-letter associations, which are necessary for the formation of the letter chunks at the sublexical and lexical levels, and therefore impairs the development of appropriate orthographic representations (Bowers & Newby-Clark, 2002; Bowers & Wolf, 1993; Wolf & Bowers, 1999). This view receives support from findings that rapid naming measures better predict the unique variance in "pure" orthographic tasks (e.g., orthographic choice tasks) and text fluency, whereas phonological factors contribute more to grapheme-phoneme decoding (Wolf et al., 2002). Moreover, Georgiou and colleagues found that the interstimulus time component of RAN correlated more strongly with orthographic knowledge than other reading measures, including phonological awareness (Georgiou, Parrila, Kirby, & Stephenson, 2008). However, other studies dispute this view. For example, Moll, Fussenegger, Willburger, and Landerl (2009) showed that whereas rapid naming was more strongly related to both word and nonword reading fluency, phonological awareness accounted for more variance in

orthographic spelling skills. In addition, Papadopoulos and colleagues (2009), testing the double-deficit hypothesis in the Greek orthography, found better orthographic processing skills in the single naming-deficit group even when compared to the control group. Other mechanisms that have been suggested as potential explanations for the rapid naming–reading relationship include a general processing speed deficit (Kail, Hall, & Caskey, 1999) and a failure to efficiently integrate orthographic/visual and phonological information (Bowers & Ishaik, 2003), among others (see also Lervåg & Hulme, 2009). To summarize, a consensus regarding the status of the double-deficit hypothesis—whether other mechanisms than phonological processing factors influence reading development and whether rapid naming contributes independently to this development—has thus far not been forthcoming.

The main objective of the present study was to investigate the existence of distinct dyslexic subtypes in a Portuguese sample, with a particular focus on identifying dyslexic readers characterized by naming difficulties but intact phonological skills. We also tested the specific influence of naming skills on reading ability; i.e., whether the relationship between rapid naming and reading performance is mediated through phonological processes or if rapid naming predicts a unique variance component in reading performance. Given the possibility that the level of orthographic consistency might influence the way that reading disorders are manifested (Seymour, Aro, & Erskine, 2003), it is important to investigate whether the subtypes predicted by the double-deficit hypothesis can be found in our sample; Portuguese orthography is placed at an intermediate position between consistent (shallow) and inconsistent (deep) orthographies (Seymour et al., 2003). If reading development depends more strongly on adequate rapid naming than phonological awareness in the relatively consistent Portuguese orthography, then the subtypes predicted by the double-deficit hypothesis should present themselves differently than in the inconsistent English orthography. We expect that pure single naming-deficit subjects should be clearly identified and also that the proportion of subjects with this profile will be greater than in other studies conducted with English-speaking children. Moreover, we expect a less pronounced association between phonological skills and reading competence. We therefore investigated the performance of children diagnosed with dyslexia and a group of normal readers on reading, rapid naming and phonological tasks. One argument for the

relative lack of association between phonological awareness and reading in consistent orthographies, compared to in English, is that this effect is masked by a ceiling effect in phonological accuracy measures (Caravolas, Volin, & Hulme, 2005). The “intermediate” nature of Portuguese orthography leads us to suggest that this is less likely to be the case in this study; nevertheless, we included a phonological processing speed measure. We also included a reading fluency measure, since reading fluency should be a better indicator of reading expertise than reading accuracy in more consistent orthographies.

## METHOD

### Participants

Twenty-two Portuguese dyslexic children (13 males and 9 females; mean age ( $\pm SEM$ ) = 9.5 ( $\pm 1.3$ ) years) were recruited through hospitals and private clinics. All had a formal diagnosis of dyslexia. The inclusion criteria for the dyslexic participants were: normal-range intelligence measured by the Wechsler Intelligence Scale for Children, 3rd ed. (WISC-III; Wechsler, 2006); reading abilities significantly below grade mean level (see below); absence of neurological, emotional or attention problems. Reading scores were converted into *z*-scores with reference to normative data. Only those subjects who had reading speed scores 1.5 *SD* below the grade mean level of the normative sample were included in the dyslexic group. The dyslexic group was matched with 22 normal readers (13 males and 9 females; mean age ( $\pm SEM$ ) = 9.1 ( $\pm 0.9$ ) years), which were classified by their teachers as average pupils. All controls had intelligence scores in the normal range (WISC-III) and reading scores within or above the average. Informed consent was obtained from all the parents of participants in compliance with the Helsinki Declaration.

### Stimuli and procedures

All tasks were adapted from the Differential Diagnosis Dyslexia Battery (Blomert & Vaessen, 2009). Normative data for the Portuguese children were collected in a large-scale study with 540 children from second to fourth grade (Reis et al., 2010). The tasks were displayed on a computer screen, using Presentation software (version 11.0; Available from <http://nbs.neurobs.com/presentation>).



## Reading test

Reading achievement was assessed by two word lists selected from a Portuguese lexical database (Fáisca, Bramão, Araújo, Pacheco, & Reis, 2006), according to word frequency (the first list included high-frequency items and the second contained low-frequency items). Each list was composed of 75 stimuli distributed on five sheets (15 stimuli per sheet) of increasing difficulty with respect to the number of syllables (from two to four syllables), syllabic structure (with and without consonant clusters), and phoneme–grapheme correspondence rules (regular and irregular correspondence rules). For each list, the children had 30 s to read aloud as many words as possible. Reading speed was computed as the number of correctly read words per second.

## Phonological awareness

Phonological awareness was tested using a phoneme deletion task. Forty-four pseudowords were created by manipulation of word length (monosyllabic and disyllabic), syllabic structure (with and without consonant clusters), and position of the phoneme to be deleted (at the beginning, middle, or end of the stimulus). Pseudowords were ordered by four levels of increasing difficulty. Subjects listened (via headphones) to a given stimulus followed by the specific phoneme to be deleted, and they were instructed to repeat the resulting pseudoword without that specified phoneme. All plausible pronunciations were considered. The examiner pressed a button as soon as the subject gave an answer, and response times were automatically computed (time between stimulus offset and the button press). The percentage of correct responses was computed and used as the main dependent measure (phonological accuracy). Additionally, phonological processing speed was considered, and it was calculated by averaging the response latencies between the presentation of the word and the oral response (only correct answers were analyzed).

## Rapid naming repetition

A rapid naming repetition task with letters was designed based on the classical paradigm by Denckla and Rudel (1976). Five different stimuli were selected (a, d, o, p, and t) and visually presented in two blocks. Each block had three columns of five stimuli, and thus each stimulus was repeated three times per block presentation

(15 items per block). Although the number of items in the rapid naming task was different than that in the original paradigm (which used 50 stimuli in total), it is unlikely that this influences the strength of the relationship with reading, as the set size of items to be retrieved from long-term memory was kept the same (i.e., five items) (Georgiou et al., 2008). Subjects were instructed to name the stimuli as quickly and accurately as possible. The number of correctly named items per second was considered as a measure of rapid naming speed.

## Statistical analysis

Raw scores of all measures were converted into  $z$ -scores with reference to the normative sample (stratified by grade) and were used for all of the analyses. To explore the existence of different subtypes of dyslexic readers, a  $z$ -score of  $-1$  was taken as the cutoff for phoneme deletion and rapid naming repetition measures. To determine the effect of phonological and rapid naming measures on reading ability, hierarchical regression analyses were conducted for both groups. For all inferential analysis,  $p$ -level was set at .05.

## RESULTS

There were significant differences between groups in all tasks, with dyslexic subjects performing below their normal controls on reading speed (dyslexics =  $-1.9 \pm 0.52$ ; controls =  $1.1 \pm 0.81$ ;  $p < .001$ ), phoneme deletion accuracy (dyslexics =  $-1.3 \pm 0.53$ ; controls =  $1.1 \pm 0.66$ ;  $p < .001$ ), phoneme deletion speed (dyslexics =  $-0.5 \pm 1.15$ ; controls =  $0.6 \pm 0.90$ ;  $p < .001$ ) and rapid naming speed (dyslexics =  $-1.2 \pm 1.13$ ; controls =  $0.7 \pm 0.87$ ;  $p < .001$ ) measures.

In order to investigate whether different subtypes of dyslexics could be identified in our sample, an analysis of the dyslexics' performance in rapid naming and phonological awareness accuracy was conducted. Since our measure of phonological awareness accuracy seems to be sensitive enough (ceiling effects were not observed in our study), we decided to use this measure rather than the phonological processing speed. A raw score of at least 1  $SD$  below the grade mean of the normative sample ( $z \leq -1$ ) was taken as the cutoff to explore the existence of different subtypes: Dyslexic readers who presented both phonological and rapid naming impairments were classified as the *double-deficit subtype* (DD); subjects showing only a rapid naming deficit,

with an average phonological score, were classified as the *single naming-deficit subtype* (ND); subjects with below-average phonological skills but average rapid naming skills were included in the *single phonological-deficit subtype* (PD); subjects who, despite showing impaired reading, did not fit any of the specified criteria were included in the undetermined group. Our descriptive results were consistent with the double-deficit hypothesis, with 50% ( $n=11$ ) of subjects placed in the DD group, 18.2% ( $n=4$ ) in the ND, 18.2% ( $n=4$ ) in the PD, and 13.6% ( $n=3$ ) as belonging to the undetermined group. The subgroup classification showed an overall significant subtype effect (the undetermined group was not considered) on reading performance (K-W Test:  $\chi^2=7.1$ ,  $df=2$ ,  $p=.029$ ). The DD group showed the poorest reading results compared to both the ND and PD subtypes, but only the comparisons with the ND group reached statistical significance (Mann-Whitney test, DD vs. ND:  $p=.013$ ; DD vs. PD:  $p=.102$ ); the PD and ND groups performed similarly ( $p=.77$ ).

A recent study questioned the finding of dyslexics with a pure rapid naming deficit, if more sensitive measures of phonological awareness are used (Vaessen et al., 2009). Vaessen and colleagues (2009) explored the performance of this subtype with measures of verbal working memory and phonological awareness speed. Within the sample characterized by a single naming deficit, they observed that only 5.5% did not show phonological problems of some kind. In order to investigate whether the ND subtype in our sample showed signs of subtle phonological difficulties, we repeated the analysis considering the phoneme deletion speed measure and the scores from a phonological short term memory

task (in which children were auditorily presented with phoneme sequences that they were asked to repeat in the same order; sequence lengths: 2–9 phonemes). Even when the phonological processing speed and working memory spans (i.e., the largest sequences correctly repeated) were included, the analysis showed that the pattern of results remained unchanged: The subjects who belonged to the single naming deficit subtype still performed within the normal range on these phonological measures.

### Regression analyses

To determine the effect of phonological and rapid naming measures on reading ability, hierarchical regression analyses were conducted for both groups. In these analyses, intelligence and vocabulary scores (measured by the vocabulary test from WISC-III) were entered first. The reading score was entered as the dependent variable, and phoneme deletion (accuracy) and rapid naming were entered as explanatory variables. In Model 1, phoneme deletion was entered first and rapid naming was entered in a second step; in Model 2, the order of entry was reversed. In these analyses, the increase in variance associated with the last variable entered in the regression represents the variable's unique contribution to the reading score (Table 1). Since the relation between intelligence and vocabulary scores was distorted by the presence of an outlier subject in the dyslexic group, this participant was not included in the regression analysis.

The results showed that the unique contribution of phoneme deletion to reading was significant in the dyslexic sample (14.6%). Moreover, for this group, after controlling for phoneme deletion,

**TABLE 1**  
Hierarchical regression analyses predicting reading skills: Unique variance accounted by phoneme deletion accuracy and rapid naming repetition

	<i>Dyslexic readers</i>				<i>Normal readers</i>			
	$R^2$	$p$	$\Delta R^2$	$\Delta p$	$R^2$	$p$	$\Delta R^2$	$\Delta p$
<i>Model 1</i>								
1. IQ full-scale (WISC)	.052	.322	.052	.322	.002	.849	.002	.849
2. Vocabulary	.295	.043	.243	.023	.238	.076	.236	.025
3. PD	.477	.010	.182	.026	.560	.002	.322	.002
4. RNR	.665	.001	.188	.009	.563	.005	.003	.727
<i>Model 2</i>								
3. RNR	.519	.005	.229	.012	.350	.047	.112	.095
4. PD	.665	.001	.146	.018	.563	.005	.213	.010

WISC, Wechsler Intelligence Scale for Children; PD, phoneme deletion; RNR, rapid naming repetition.

rapid naming still made a significant contribution to reading performance (18.8%), which rules out the possibility that the effect of rapid naming on reading is totally mediated by phonological processing skills. Although the hypothesis of partial mediation is still plausible, one of the three conditions necessary for mediation (Baron & Kenny, 1986) was not verified in dyslexics: The correlation between rapid naming and phoneme deletion was not significant ( $r = .066$ ,  $p = .77$ ). Therefore the mediation hypothesis should be discarded.

A different pattern of results was found for the controls, with phonological awareness being the only contributor (21.3%) to reading variance.

## DISCUSSION

The present study investigated whether distinct subtypes of dyslexic readers, as proposed by the double-deficit framework, could be identified in the relatively consistent Portuguese orthography. Of particular interest is the existence of dyslexic readers who suffer from pure rapid naming deficits in the absence of phonological problems. Such a finding strengthens the interpretation that non-phonological processes underlying the naming deficits contribute to reading failure in dyslexia. To clarify the independent contributions of the processes subserving rapid naming and the phonological deficits in dyslexia (another main assumption of the double-deficit hypothesis), regression analyses were performed to verify whether rapid naming predicts reading fluency after controlling for the effects of phonological awareness (either accuracy or speed).

The literature related to the double-deficit hypothesis is controversial. Some studies suggest that phonological awareness represents a universal predictor for reading development and that rapid naming has only a minor influence (for a recent cross-language study, see Ziegler et al., 2010). Others suggest that when the phonological demands are reduced (as in the case of consistent orthographies), phonological awareness is relatively less important, whereas the predictive value of rapid naming is consistently significant over developmental time (Landerl & Wimmer, 2008). This apparent discrepancy might stem from the fact that the role of phonological awareness was mainly investigated in the early reading stages of reading development (e.g., Ziegler et al., 2010). One possibility is that phonological awareness is crucial in early reading development, whereas the factors underlying rapid naming skills are

important throughout or become important slightly later in reading development.

In the present study, the dyslexic children showed poorer performance than the controls on reading speed, rapid naming speed, and phonological awareness (both accuracy and processing speed). Consistent with the double-deficit hypothesis (Wolf & Bowers, 1999), distinct subtypes of dyslexics were found in the Portuguese sample. Specifically, dyslexic readers were characterized by a single deficit at the level of either phonological processing or rapid naming (18.2% in each subtype) or by the co-occurrence of the two (50% of the subjects). The existence of dyslexics with naming difficulties despite normal (average) phonological skills lends support to the claim of Wolf and Bowers (1999) that rapid naming represents a second core deficit in dyslexia that is independent of phonology. However, Vaessen and colleagues (2009) questioned this, arguing that these subjects exhibit phonological deficits when more sensitive measures (e.g., phonological processing speed and verbal working memory) are investigated. To examine this claim, we reanalyzed the performance of the single naming-deficit subtype, including phonological processing speed and phonological short-term memory capacity. The results showed that all of the subjects of this subtype performed within an average range in terms of both phonological processing speed and verbal working memory, corroborating the existence of dyslexics with an isolated rapid naming impairment.

In our study, we found an equal number of subjects of each single-deficit subtype. This finding seems to suggest that the role of rapid naming skills is more important in more consistent orthographies than it is in English orthography. In addition, rapid naming deficits might be more persistent in impaired readers with average phonological skills or compensated phonological problems. This possibility is consistent with the findings by Papadopoulos and colleagues in a consistent (Greek) orthography, which suggests that the single phonological-deficit subtype converged on the same reading performance level as the control group by the second grade, in contrast to the single naming-deficit group (2009).

Another assumption of the double-deficit hypothesis is that there is a cumulative effect of rapid naming and phonological difficulties in the double-deficit subtype, which leaves these subjects without an effective compensatory strategy for reading development (i.e., grapheme-phoneme decoding for phonological measures or orthographic identification for rapid naming measures)



(Wolf & Bowers, 1999). When we compared the reading performance among the dyslexic subtypes in this study, we found that the double-deficit subgroup achieved worse reading speed scores than the single-deficit subgroups. However, in the view of Schatschneider and colleagues (2002), the severity of the double-deficit subtype might reflect an artifact of grouping children based on their performance on two (presumably) correlated measures (rapid naming and phonological awareness). A positive correlation might result in lower scores on phonological awareness and rapid naming measures for the double-deficit subgroup in comparison to the single-deficit subgroups. In line with this idea, these authors argue that the prominent reading problems exhibited in the double-deficit subtype are caused not by an additive impact of the two deficits but instead by the relatively greater severity of one of these deficits. We tested the correlation between phonological awareness and rapid naming in our dyslexic sample and found no indication of an association between these behavioral dimensions (rapid naming and phoneme deletion accuracy:  $r = .066$ ,  $p = .77$ ; rapid naming and phoneme deletion speed:  $r = .125$ ,  $p = .60$ ). Moreover, when we compared phonological awareness and rapid naming scores in the double-deficit vs. the phonological and naming deficit subgroups, we found no statistically significant differences between the groups (DD vs. PD:  $p = .327$ , DD vs. ND:  $p = .794$ ; Mann-Whitney test). Taken together, it thus seems unlikely that the severity of the double-deficit subtype is the result of an artifact in our study. Instead, the results suggest that rapid naming and phonological problems contribute in parallel to the greater reading difficulty observed in the double-deficit group.

Closely related to the notion of dyslexic subtypes and the additive effect that rapid naming and phonological deficits have on reading development is the fundamental assumption of the independence of the processes underlying rapid naming and phonological processing skills. In the present study, regression analyses were used to investigate this assumption. The results showed that rapid naming skills contribute uniquely to reading development, and this contribution persists after controlling for the effects of vocabulary, intelligence level, and phonological processing skills. These findings appear inconsistent with the idea that the mechanism mediating the relationship between rapid naming and reading development is phonological in nature (Chiappe et al., 2002). Instead, it is probably that non-phonological components subserving rapid

naming performance play a significant role in reading development (e.g., Wolf et al., 2000). Moreover, in line with previous results, rapid naming proved to be a stronger predictor in the less proficient readers (Johnston & Kirby, 2006; McBride-Chang & Manis, 1996), and rapid naming skills did not explain individual variability in the control group. The reason for this is not completely understood. McBride-Chang and Manis (1996) have argued that good readers are close to “automatic” in their performance in the early stages of reading development, approaching asymptotic naming performance by the end of the second or third grade. Subsequently, rapid naming loses its predictive value in the sense of explaining individual differences in reading skills in proficient readers. By contrast, impaired readers rarely become fully “automatized” and, therefore, rapid naming measures remain a good predictor of reading development and reading skills for this group. The present findings also suggest that the processes that rapid naming requires are important factors in reading difficulties.

We found a different pattern of results regarding the relationship between reading performance and phonological awareness. The phonological awareness accuracy measure accounted for reading variance in both normal and dyslexic readers. This is in agreement with the assumption that phonological skills are intimately related to reading ability in alphabetic orthographies, given that learning to read relies on learning to map alphabetic symbols to sounds (Velutino, Fletcher, Snowling, & Scanlon, 2004). In this study, phonological awareness skills showed a somewhat less explanatory value in dyslexics than in normal readers. Thus, in orthographies with an intermediate orthographic depth, the contribution of phonological awareness to reading failure is attenuated in comparison to English orthography. These results support the idea that the influence of some predictors on reading is weighted by the orthographic consistency in alphabetic languages (for a review, see Sprenger-Charolles, Serniclaes, & Colé, 2006; Vaessen et al., in press).

Some limitations of the present study should be noted. It investigated a relatively small sample of dyslexic children, and the lack of a control group matched for reading level makes it difficult to entirely rule out the possibility that the pattern of results might be reduced to a developmental delay. In light of previous results, however, we think that this explanation is unlikely.

In conclusion, the present study provides evidence for the existence of a dyslexic subtype characterized by pure naming deficits in the

absence of phonological problems. This finding, together with the results suggesting a unique contribution of rapid naming to reading performance in dyslexics, is not easily accommodated by an exclusively phonological explanation for rapid naming and reading problems in dyslexia. Instead, the results suggest that non-phonological processes, which subserve rapid naming, contribute independently to reading development.

Manuscript received July 2009

Revised manuscript accepted May 2010

First published online September 2010

## REFERENCES

- Ackerman, P. T., & Dykman, R. A. (1993). Phonological processes, confrontational naming, and immediate memory in dyslexia. *Journal of Learning Disabilities, 26*(9), 597–609.
- Badian, N. A. (1997). Dyslexia and the double-deficit hypothesis. *Annals of Dyslexia, 47*, 69–87.
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173–1182.
- Blomert, L., & Vaessen, A. (2009). *Differentiaal Diagnostiek van Dyslexie; Cognitieve analyse van lezen en spellen* [Dyslexia differential diagnosis; Cognitive analysis of reading and spelling]. Amsterdam: Boom.
- Bowers, P. G., & Ishaik, G. (2003). RAN's contribution to understanding reading disabilities. In S. Graham, H. Swanson, & K. R. L. Harris (Eds.), *Handbook of learning disabilities* (pp. 140–157). New York: Guilford.
- Bowers, P. G., & Newby-Clark, E. (2002). The role of naming speed within a model of reading acquisition. *Reading and Writing, 15*, 109–126.
- Bowers, P. G., & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skill in dyslexia. *Reading and Writing, 5*, 69–85.
- Caravolas, M., Volin, J., & Hulme, C. (2005). Phoneme awareness is a key component of alphabetic literacy skills in consistent and inconsistent orthographies: Evidence from Czech and English children. *Journal of Experimental Child Psychology, 92*, 107–139.
- Chiappe, P., Stringer, R., Siegel, L. S., & Stanovich, K. E. (2002). Why the timing deficit hypothesis does not explain reading disability in adults. *Reading and Writing, 15*, 73–107.
- Clarke, P., Hulme, C., & Snowling, M. (2005). Individual differences in RAN and reading: A response timing analysis. *Journal of Research in Reading, 28*(2), 73–86.
- Denckla, M. B., & Cutting, L. E. (1999). History and significance of rapid automatized naming. *Annals of Dyslexia, 49*, 29–42.
- Denckla, M. B., & Rudel, R. G. (1976). Rapid “automatized” naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia, 14*, 471–479.
- Escribano, C. L. (2007). Evaluation of the double-deficit hypothesis subtype classification of readers in Spanish. *Journal of Learning Disabilities, 40*(4), 319–330.
- Faisca, L., Bramão, I., Araújo, S., Pacheco, A., & Reis, A. (2006, November). *Corpus linguístico constituído a partir de manuais escolares* [Linguistic corpus from children textbooks]. Paper presented at the VI Simpósio Nacional de Investigação em Psicologia, Universidade de Évora.
- Faust, M., & Sharfstein-Friedman, S. (2003). Naming difficulties in adolescents with dyslexia: Application of the tip-of-the-tongue paradigm. *Brain and Cognition, 53*, 211–217.
- Fawcett, A. J., & Nicolson, R. I. (1994). Naming speed in children with dyslexia. *Journal of Learning Disabilities, 27*, 641–646.
- Georgiou, G. K., Parrila, R., Kirby, J. R., & Stephenson, K. (2008). Rapid naming components and their relationship with phonological awareness, orthographic knowledge, speed of processing, and different reading outcomes. *Scientific Studies of Reading, 12*(4), 325–350.
- Johnston, T. C., & Kirby, J. R. (2006). The contribution of naming speed to the simple view of reading. *Reading and Writing, 19*, 339–361.
- Kail, R., Hall, L. K., & Caskey, B. J. (1999). Processing speed, exposure to print, and naming speed. *Applied Psycholinguistics, 20*, 303–314.
- Kirby, J. R., Parrila, R. K., & Pfeiffer, S. L. (2003). Naming speed and phonological awareness as predictors of reading development. *Journal of Educational Psychology, 95*(3), 453–464.
- Kirby, J. R., Roth, L., Desrochers, A., & Lai, S. (2008). Longitudinal predictors of word reading development. *Canadian Psychology, 49*(2), 103–110.
- Landerl, K., & Wimmer, H. (2000). Deficits in phoneme segmentation are not the core problem of dyslexia: Evidence from German and English children. *Applied Psycholinguistics, 21*, 243–262.
- Landerl, K., & Wimmer, H. (2008). Development of word reading fluency and spelling in a consistent orthography: An 8-year follow-up. *Journal of Educational Psychology, 100*(1), 150–161.
- Lervåg, A., & Hulme, C. (2009). Rapid automatized naming (RAN) taps a mechanism that places constraints on the development of early reading fluency. *Psychological Science, 20*(8), 1040–1048.
- Manis, F. R., Doi, L. M., & Bhadha, B. (2000). Naming speed, phonological awareness, and orthographic knowledge in second graders. *Journal of Learning Disabilities, 33*(4), 325–333.
- McBride-Chang, C., & Manis, F. R. (1996). Structural invariance in the associations of naming speed, phonological awareness, and verbal reasoning in good and poor readers: A test of the double deficit hypothesis. *Reading and Writing, 8*, 323–339.
- Moll, K., Fussenegger, B., Willburger, E., & Landerl, K. (2009). RAN is not a measure of orthographic processing: Evidence from the asymmetric German orthography. *Scientific Studies of Reading, 13*(1), 1–25.
- Papadopoulos, T. C., Georgiou, G. K., & Kendeou, P. (2009). Investigating the double-deficit hypothesis in Greek. *Journal of Learning Disabilities, 42*(6), 528–547.

- Reis, A., Castro, S. L., Inácio, F., Pacheco, A., Araújo, S., Santos, M., et al. (2010). *Versão Portuguesa da Bateria 3DM para avaliação da leitura e da escrita* [3DM Portuguese version to assess reading and spelling skills]. Manuscript in preparation.
- Schatschneider, C., Carlson, C. D., Francis, D. J., Foorman, B. R., & Fletcher, J. M. (2002). Relationship of rapid automatized naming and phonological awareness in early reading development: Implications for the double-deficit hypothesis. *Journal of Learning Disabilities, 35*(3), 245–256.
- Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology, 96*, 265–282.
- Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94*, 143–174.
- Sprenger-Charolles, L., Serniclaes, W., & Colé, P. (2006). *Reading acquisition and developmental dyslexia*. New York: Psychology Press.
- Swan, D., & Goswami, U. (1997). Picture naming deficits in developmental dyslexia: The phonological representations hypothesis. *Brain and Language, 56*, 334–353.
- Truman, A., & Hennessey, N. W. (2006). The locus of naming difficulties in children with dyslexia: Evidence of inefficient phonological encoding. *Language and Cognitive Processes, 21*(4), 361–393.
- Vaessen, A., Bertrand, D., Tóth, D., Csépe, V., Faisca, L., Reis, A., et al. (in press). Cognitive development of fluent word reading does not qualitatively differ between transparent and opaque orthographies. *Journal of Educational Psychology*.
- Vaessen, A., Gerretsen, P., & Blomert, L. (2009). Naming problems do not reflect a second independent core deficit in dyslexia: Double deficits explored. *Journal of Experimental Child Psychology, 103*(2), 202–221.
- Velutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, 45*(1), 2–40.
- Vukovic, R. K., & Siegel, L. S. (2006). The double-deficit hypothesis: A comprehensive analysis of the evidence. *Journal of Learning Disabilities, 39*(1), 25–47.
- Wechsler, D. (2006). *Wechsler Intelligence Scale for Children – Third Edition (WISC-III)*. Lisbon, Portugal: Cegoc-Tea.
- Wolf, M., & Bowers, P. G. (1999). The double-deficit hypothesis for the developmental dyslexias. *Journal of Educational Psychology, 91*(3), 415–438.
- Wolf, M., Bowers, P. G., & Biddle, K. (2000). Naming-speed processes, timing, and reading: A conceptual review. *Journal of Learning Disabilities, 33*(4), 387–407.
- Wolf, M., O'Rourke, A. G., Gidney, C., Lovett, M., Cirino, P., & Morris, R. (2002). The second deficit: An investigation of the independence of phonological and naming-speed deficits in developmental dyslexia. *Reading and Writing, 15*, 43–72.
- Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faisca, L., et al. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science, 21*(4), 551–559.