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Rapid serial naming: Developmental trajectory and relationship with the Bangor Dyslexia Test in Spanish students

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This study aimed to analyse the developmental trajectory of the accuracy and speed of naming among dyslexics and developing readers from 1st to 6th grade of primary education. It examined how familiarity with the stimulus influences the performance of different naming tasks in both groups and evaluated the link between naming speed and the Bangor Dyslexia Test. With a descriptive and correlational design, eight naming tasks and the Bangor Dyslexia Test (Miles, 1982; Outón & Suárez, 2010) were administered to a sample of 198 dyslexics and 245 developing readers. The results showed that the dyslexics were slower and more inaccurate in all the naming tasks, compared with the developing readers of the same age. Greater difficulty was observed with the less familiar stimuli. It became evident that naming performance improved with age among both groups of subjects. Finally, a greater number of significant and positive correlations were found between the naming tasks and the Bangor Dyslexia Test in the dyslexic group; the strongest relationship was obtained by naming letters.

KEYWORDS

Bangor Dyslexia Test, development of rapid serial naming, dyslexia, primary education, serial naming, Spanish

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1 | INTRODUCTION

More than half a century ago, Geschwind and Fusillo (1966) suggested that reading difficulties could be related to a deficit in colour naming, observing that both difficulties shared brain circuits in the form of pure alexia without agraphia. Denckla and Rudel (1976a, 1976b) examined this hypothesis and found that dyslexics differed from typically developing readers and from children with learning problems in terms of serial naming speed, not only of colours, but also of known letters, numbers, and objects. The stimuli employed in these studies comprised of the prototype of the Rapid Automatised Naming (RAN) tests, which are used in most research studies to assess naming ability. These tests involve presenting familiar stimuli in a linear sequence, random repetition several times, and access to a single semantic category. However, variants of the same tests have also been used. Other forms include use of alternating stimuli of two or more series (Albuquerque & Simões, 2010; Wolf, 1986) in a discrete format, in which stimuli are presented individually (Bowers & Swanson, 1991; Chiappe, Stringer, Siegel, & Stanovich, 2002; Georgiou, Parrila, Cui, & Papadopoulos, 2013), or with all the different elements. In the latter, it is assumed that the requirements for phonological coding are greater (Di Filippo, Zoccolotti, & Ziegler, 2008).

The relationship between performance in rapid naming tasks and reading has been widely researched, and it has been proven to be correlated with different reading processes. Thus, it has been linked to the knowledge of the name and sound of the letters (Ferroni & Diuk, 2010), the accuracy and reading speed of words and pseudo-words (Altani, Protopapas, & Georgiou, 2018; Clarke, Hulme, & Snowling, 2005; Savage et al., 2018; Swanson, Trainin, Necoechea, & Hammill, 2003), reading fluency of texts (Georgiou, Papadopoulos, & Kaizer, 2014; van de Ven, Voeten, Steenbeek-Planting, & Verhoeven, 2017), and reading comprehension (Joshi & Aaron, 2000; Layes, Lalonde, & Rebaï, 2016; Tong, McBride, Shu, & Ho, 2018). Araújo, Reis, Petersson, and Faísca (2015) found a moderate to strong correlation between the naming tasks and reading of words, pseudo-words, texts, and reading comprehension in a recent meta-analysis study of reading of words and texts obtaining the highest coefficients. In addition, different studies suggest that serial naming has a superior effect on the prediction of reading performance compared to discrete naming (Altani et al., 2018; Altani, Protopapas, & Georgiou, 2017; Georgiou et al., 2013). Both tasks involve similar cognitive processes: sequential eye movements through the page (saccades and jumping to the next line), visual discrimination of the stimulus presented at fixation, integration of the visual information into the mental representation, phonological patterns of the stimulus, access and recovery of the phonological label, activation and integration of semantic information, and pronunciation of the stimulus name. Moreover, some authors argue that RAN is a microcosmic representation of reading (Norton & Wolf, 2012). However, there is currently no consensus on which of these processes are deficient in both tasks (Jones, Snowling, & Moll, 2016).

Furthermore, the naming tasks provided a distinction between dyslexics and typically developing readers in languages with different degrees of orthographic regularity. This was seen in a wide set of cases from regular languages (e.g., German: Brandenburg et al., 2017; SpanishJiménez et al., 2009; Greek: Georgiou, Papadopoulos, Zarouna, & Parrila, 2012; Dutch: Bexkens, van den Wildenberg, & Tijms, 2015; Italian: Tobia & Marzocchi, 2014; Polish: Żesławska-Faleńczyk & Małyszczak, 2016) to more opaque languages (French: Ziegler, Castel, Pech-Georgel, & George, 2008; English: Raschle, Chang, & Gaab, 2011; Portuguese: Araújo et al., 2011) and non-alphabetic languages (Chinese: Tong, McBride, Lo, & Shu, 2017; Japanese: Wakamiya et al., 2011). Following the same line, Landerl et al. (2013) found, in a study involving 1,138 typically developing readers and 1,114 dyslexics from eight European countries, that phonemic awareness and RAN are strong predictors of dyslexia in the six languages spoken by the participants (Finnish, Hungarian, German, Dutch, French, and English). The findings of these and other studies in different languages suggest that rapid naming is an early predictor of dyslexia and could be used for detection and intervention before reading difficulties arise.

Despite this predictive character of dyslexia and its relationship with different reading processes, there are still many unresolved issues regarding rapid naming, including its developmental trajectory, the type of stimuli used in these tasks, and its relationship with other tests to detect dyslexia, among others.

With respect to its developmental trajectory, several studies conducted so far include small samples of two or three age groups or different school years, but few include a wide range of ages. The latter include: in Chinese, the study conducted by Ding, Richman, Yang, and Guo (2010), who verified the abilities to name colours, objects, and numbers, and the processes of immediate memory in a sample of 243 schoolchildren from 1st to 5th grade; in Spanish, the work conducted by Jiménez, Rodríguez, Guzmán, and García (2010), who assessed the speed of naming letters, numbers, colours, and drawings, along with other cognitive processes, in a sample of 1,050 Primary Education students from the 2nd to the 6th grade; in Greek, the study performed by Georgiou et al. (2014), who examined both the articulation times and pause times in naming digits and objects in 75 schoolchildren enrolled in 1st, 2nd, 4th, 6th, and 10th grade; in English, the research conducted by Wolf and Denckla (2005), and Wiig, Zureich, and Chan (2000), who assessed 1,461 subjects aged 5 to 18 years in tasks of naming objects, colours, numbers, and letters, and 2,450 subjects aged from 6 to 21 years in tasks of naming colours, geometric shapes, and a combination of both, respectively; and in English and Kannada, the study conducted by Siddaiah, Saldanha, Venkatesh, Ramachandra, and Padakannaya (2016), who administered naming tests of letters, digits, objects, and colours in both languages to 600 students enrolled in the 1st to 10th grade. However, the vast majority of these research studies did not include a comparison of the developmental trajectory between dyslexics and typically developing readers, nor was there an agreement on the age at which the maximum speed for different stimuli is reached. For instance, Wolf and Denckla (2005) observed the highest speed in colour naming at 14 years of age, whereas in the study conducted by Siddaiah et al. (2016), it was as high as 16 years old.

In relation to the type of stimulus, most studies have examined naming speed using the same tasks as Denckla and Rudel (1976a, 1976b), and few have examined the developmental trajectory of the accuracy and speed of naming with stimuli of other semantic categories. Among the latter, geometric shapes should be mentioned (Albuquerque & Simões, 2010; Wiig et al., 2000), along with animals (Catts, Gillispie, Leonard, Kail, & Miller, 2002) or Chinese characters (Liao & Parrila, 2008). The degree of familiarity of the labels and whether they lead to differences between dyslexics and typically developing readers have not been considered.

Another unknown aspect of the naming tests is their relationship with other instruments for the detection and diagnosis of dyslexia, which assesses cognitive-behavioural manifestations other than written language. These include working memory (Aguilar-Vafaie, Safarpour, Khosrojavid, & Afruz, 2012; Cowan et al., 2017; Weng, Li, & Li, 2016) or auditory discrimination (Banai & Ahissar, 2018; Bogliotti, Serniclaes, Messaoud-Galusi, & Sprenger-Charolles, 2008; Witton, Swoboda, Shapiro, & Talcott, 2019), among others. According to Norton and Wolf (2012), dyslexia is a heterogeneous disorder, and despite more than 100 years of research on this disorder, there is neither an explanation for all its symptoms nor an understanding of how they relate to each other. Given our previous studies on the Bangor Dyslexia Test (BDT) (Outón & Suárez, 2010), we made the most of the research by studying the relationships that rapid naming may have, with the subtests making up the Bangor test. The aim was to examine whether we could find any interesting relationships, since Miles (1993) believed, a posteriori, that its diagnostic power consists of a phonological component in all the tasks of the test. More specifically, the belief relates to the difficulty of finding the right word, and this was the component at which dyslexics failed. However, this relationship has not yet been studied.

2 | METHODOLOGY

2.1 | Aims of the study

The main objectives of this study were to analyse the developmental trajectory of the accuracy and speed of naming by dyslexics and typically developing readers from the 1st to 6th grade of primary education. We focused on examining how familiarity with the stimulus influences performance of different naming tasks in both groups of subjects and evaluating how naming speed is related to the BDT.

2.2 | Sample

The sample consisted of 443 primary education students (198 dyslexics and 245 typically developing readers), aged between 6 and 12 years, belonging to different schools located in the autonomous communities of Galicia and Catalonia (271 from Galicia and 172 from Catalonia). Students with dyslexia were recruited through guidance departments and psychopedagogical centres. The inclusion criteria for this group were expert opinions or assessments in which the diagnosis of dyslexia was explicit; IQ score ≥ 85 in order to exclude intellectual disability; reader performance below the average level of the class; absence of uncorrected neurological, psychic, or sensory disorders; and lack of proficiency in the language of academic instruction. Only two of these criteria—intelligence and reading delay—were directly verified for 45 dyslexics; for the others, the anamnesis information was used. The typically developing readers were selected from the same schools as the dyslexic students and classified by their teachers as students without reading and writing difficulties, and with average intellectual capacity. Table 1 presents the distribution of the samples.

To study how naming speed is related to the BDT, a subsample of 121 2nd to 6th grade primary education students (45 dyslexics and 76 typically developing readers) were considered from the original sample ($N = 443$). All the tasks in the test were administered to them, except for the 'multiplication table' item, which was only administered to 31 dyslexics and 63 typically developing readers, since some of the 7- or 8-year-old children had not yet had the opportunity to learn multiplication. Table 2 presents the characteristics of this subsample.

2.3 | Instruments

Assessment of verbal labelling (Outón, 2003) is based on the RAN test developed by Denckla and Rudel (1974). Its purpose is to evaluate the naming accuracy and speed in eight different tasks: series of fruits, series of animals, series of

TABLE 1 Mean and standard deviations of age according to the group and grade for the naming tasks

	Dyslexics			Typical readers		
	Age			Age		
Grade	*N*	*M*	*SD*	*N*	*M*	*SD*
1st	14	6.4	0.05	25	6.7	0.4
2nd	30	7.3	0.5	44	7.7	0.6
3rd	46	8.4	0.8	28	8.2	0.8
4th	44	9.1	0.4	66	9.5	0.6
5th	45	10.2	0.6	42	10.5	0.6
6th	19	11.4	0.5	40	11.4	0.5
Total	198	8.9	1.5	245	9.2	1.6

TABLE 2 Mean and standard deviations of age according to the group and grade for the Bangor Dyslexia Test

	Dyslexics			Typical readers		
	Age			Age		
Grade	*N*	*M*	*SD*	*N*	*M*	*SD*
2nd	12	7.1	0.6	18	7.4	0.5
3rd	12	8.6	0.7	11	8.1	0.0
4th	10	9.2	0.5	24	9.3	0.4
5th	7	9.7	0.8	11	10.1	0.0
6th	4	11.3	0.5	12	11.2	0.3
Total	45	8.7	1.4	76	9.1	1.3

colours, series of numbers, series of musical instruments, series of objects of different categories -miscellaneous–series of spatial notions, and series of letters. The examiner presents each of the series in a DIN A-4 sheet, with a 5-column and 9-row layout, in which five stimuli are distributed, repeated nine times randomly, and make up a series of 45 stimuli. Specifically, the following were presented as stimuli: five fruits known to children (apple, orange, banana, lemon, and pear), five animals (dog, cat, pig, rooster, and mouse), five basic colours (black, green, blue, red, and yellow), five one-figure numbers (one, five, six, seven, and nine), five musical instruments (piano, guitar, drum, trumpet, and tambourine), five familiar objects of different semantic fields (turtle, umbrella, flashlight, wheelbarrow, and sledge), five spatial notions (centre, top, left, right, and bottom), and five letters (a, o, b, d, and m). According to the development of vocabulary in children aged between 6 and 13 years old (Justicia, 1995), the total frequency of use of the words in each series is as follows: fruits, 824; animals, 4,040; colours, 2,262; numbers, 1,400; musical instruments, 151; miscellaneous, 204; spatial notions, 295; and letters, 12,919. The series of letters was only administered to a small group of the sample (51 dyslexics and 62 typically developing readers), since it was incorporated into the design of the test at a later stage.

Wechsler Intelligence Scale for Children-IV, *WISC-IV (*Wechsler, *2010).* This is a standardised scale of individual application aimed at assessing the cognitive abilities of children aged between 6 years and 0 months and 16 years and 11 months old.

Reading the words of the Test of Analysis of Reading and Writing (*TALE*) (Toro & Cervera, 1990). It consists of a list of 50 words, of which six are invented words. In this study, only the number of errors and the time spent reading were considered.

Bangor Dyslexia Test (BDT) (Miles, 1982; Outón & Suárez, 2010). This is a dyslexia screening test that assesses the difficulties associated with this disorder in addition to reading and writing. It consists of 10 subtests: recognition of the right and left sides in different parts of the body, repetition of multi-syllabic words, mentally performing subtraction operations, reciting the multiplication table and the months of the year forward and backward, repetition of digits in direct and inverse order, evidence about the confusion of letters 'b' and 'd', and report of family incidence on learning difficulties.

2.4 | Procedure

The assessment of verbal labelling was administered by one of the authors and four examiners, two Catalans, and two Galicians, previously trained in the management of this test. The students were evaluated individually in a quiet room at their school or at the psychopedagogical centre they attended. The procedure for each series was identical. First, the participants were instructed in the task with two training sheets: a series of means of transport and a series of school materials. Next, the assessment began, where participants had to name, as quickly as possible, the different stimuli of each row from left to right and from top to bottom. To avoid difficulties during the activity, the participants were asked to use their index finger while naming the different stimuli. The participants had to use the correct label for each stimulus, although some synonyms were also valid. If at some point the participants forgot the name of the stimulus, they were instructed to say 'skip' or 'I don't know'. The examiner recorded the errors made, their corrections, and the execution time in seconds for each series.

The WISC-IV, TALE, and Bangor tests were administered by one of the authors according to their respective rules.

3 | RESULTS

Two multivariate analyses of variance (MANOVA) 2×6 were conducted to check whether there were significant differences between the groups (dyslexics and typically developing readers) and the school year (from 1st to 6th grade of primary education) in the different naming tasks, except for letters: (a) analysis of the errors for each of the naming tasks, and (b) analysis of the overall execution time in each of them. For the naming of letters, two ANOVA groups per grade (from 1st to 5th) were performed for the 'errors' and 'time' variables. Subsequently, the test for comparisons between groups with Bonferroni's correction was applied to analyse groups with differences.

The analysis of the number of errors yielded significant main effects due to the group, as shown in Table 3. The dyslexics committed significantly more errors than the typically developing readers in all the measured variables, with the naming of musical instruments and miscellaneous being the most difficult tasks for both groups of participants. According to their grades, statistically significant differences were also found in the mean scores of the ETV, except in letters, with the older student groups obtaining better performance in the test, compared with the younger student groups. The most difficult task for all students, regardless of their grades, was naming musical instruments. The exception was the 1st grade students, for whom, the most difficult task was naming spatial notions. The variable that caused the fewest errors was 'numbers'. The group × grade interaction was equally significant in all measured variables, except in 'colours' and 'miscellaneous'. The Bonferroni's correction confirmed significant differences in the dyslexic group among the different grades of the students: 1st vs. 2nd grade in numbers ($p < .001$); 1st vs. 3rd grade in numbers ($p < .001$) and spatial notions ($p < .001$); 1st vs. 4th grade in fruits ($p < .001$), numbers ($p < .001$), spatial notions ($p < .001$) and letters ($p < .05$); 1st vs. 5th grade in fruits ($p < .001$), numbers ($p < .001$), spatial notions ($p < .001$) and letters ($p < .05$); 1st vs. 6th grade in fruits ($p < .001$), numbers ($p < .001$), and spatial notions ($p < .001$); 2nd vs. 4th grade in fruits ($p < .001$), animals ($p < .05$), spatial notions ($p < .001$) and letters ($p < .05$); 2nd vs. 5th grade in fruits ($p < .001$), animals ($p < .001$), and spatial notions ($p < .001$); 2nd vs. 6th grade in fruits ($p < .001$), animals ($p < .05$), and spatial notions ($p < .001$); 3rd vs. 4th grade in fruits ($p < .05$) and musical instruments ($p < .05$); 3rd vs. 5th grade in fruits ($p < .001$), and 3rd vs. 6th in fruits ($p < .05$).

The analysis of execution time found that dyslexics were significantly slower than the typically developing readers in all the tasks: fruits F (1, 431) = 332.93, $p < .001$; animals F (1, 431) = 234.49, $p < .001$; colours F (1, 431) = 207.63, $p < .001$; numbers F (1, 431) = 186.63, $p < .001$; musical instruments F (1, 431) = 222.04, $p < .001$; miscellaneous F (1, 431) = 241.31, $p < .001$; spatial notions F (1, 431) = 150.34, $p < .001$, and letters F (1, 103) = 71.68, $p < .001$. Similarly, significant differences were found according to the grade, with students in higher grades being faster than those in lower grades when naming the different elements of the test: fruits F (5, 431) = 33.71, $p < .001$; animals F (5, 431) = 26.60, $p < .001$; colours F (5, 431) = 27.14, $p < .001$; numbers F (5, 431) = 44.09, $p < .001$; musical instruments F (5, 431) = 21.72, $p < .001$; miscellaneous F (5, 431) = 22.30, $p < .001$; spatial notions F (5, 431) = 37.01, $p < .001$, and letters F (4, 103) = 7.60, $p < .001$. Furthermore, significant group × grade interactions were observed in all of the variables studied, except for musical instruments F (5, 431) = .82, p = .532, as shown in Figure 1. In the 'letters' variable, the interaction was also significant, F (4, 103) = 4.88, p = .001. Table 4 shows the descriptive statistics of the execution time and a posteriori comparison with Bonferroni's correction.

To determine whether naming difficulties were related to performance in the different BDT items, we calculated the Pearson's correlation coefficient between the execution time among the different naming tasks and the scores in the different BDT subtests for a group of 45 dyslexics and 76 typically developing readers. This was not the case for the multiplication table and letter items, whose sample was reduced to 31 dyslexics and 63 typically developing readers, and 45 dyslexics and 62 typically developing readers, respectively. The results showed significant correlations in the group of typically developing readers between tasks of naming months backward and fruits (r = 0.38, p = .001), animals (r = 0.31, $p < .01$), colours (r = 0.29, $p < 0.05$), musical instruments (r = 0.31, $p < .01$), miscellaneous (r = 0.35, $p < .01$), and spatial notions (r = 0.28, $p < .05$), between the multiplication table and naming colours (r = 0.34, $p < .01$) and spatial notions (r = 0.26, $p < .05$); between subtraction and naming fruits (r = 0.27, $p < .05$), and between backward digit span and numbers (r = −0.26, $p < .05$). However, among the dyslexics group, significant and positive correlations were found among almost all items of the BDT, except in the multiplication table, which only correlated with naming spatial notions. The subtests of 'b–d' confusion, repetition of multi-syllabic words, and backward digit span obtained the highest number of significant relationships with the different naming tasks.

TABLE 3 Group X Grade MANOVA on the errors in the different naming tasks

	Group				Grade				Group × grade interaction								
Tasks		*M*	*SD*	*F* (1, 431)		*M*	*SD*	*F* (5, 431)		*N*	*M*	*SD*		*N*	*M*	*SD*	*F* (5, 431)
Fruits	D	3.1	4.6	97.82**	1	2.7	5.7	7.08**	D1	14	6.6	8.3	TR1	25	0.6	1.2	7.11**
	TR	0.4	1.3		2	2.3	3.9		D2	30	5.3	4.6	TR2	44	0.3	1.3	
					3	2.6	4.6		D3	46	4.0	5.4	TR3	28	0.3	0.6	
					4	1.2	2.5		D4	44	2.1	3.0	TR4	66	0.6	2.0	
					5	0.9	1.9		D5	45	1.5	2.5	TR5	42	0.3	0.8	
					6	0.7	1.4		D6	19	1.6	2.0	TR6	40	0.3	0.8	
Animals	D	0.6	1.6	17.51**	1	0.6	1.5	3.30**	D1	14	1.1	2.2	TR1	25	0.4	0.9	2.43*
	TR	0.1	0.5		2	0.6	2.0		D2	30	1.3	3.0	TR2	44	0.2	0.6	
					3	0.2	1.3		D3	46	0.6	1.6	TR3	28	0.0	0.2	
					4	0.2	0.6		D4	44	0.4	0.9	TR4	66	0.1	0.3	
					5	0.2	0.4		D5	45	0.2	0.4	TR5	42	0.1	0.4	
					6	0.2	0.6		D6	19	0.3	0.6	TR6	40	0.2	0.6	
Colours	D	0.8	1.7	25.63**	1	0.9	2.4	2.42*	D1	14	1.5	3.2	TR1	25	0.5	1.8	1.01
	TR	0.2	0.7		2	0.5	1.4		D2	30	1.1	2.0	TR2	44	0.2	0.5	
					3	0.5	1.4		D3	46	0.8	1.7	TR3	28	0.0	0.0	
					4	0.3	1.0		D4	44	0.6	1.5	TR4	66	0.1	0.5	
					5	0.4	0.7		D5	45	0.6	0.8	TR5	42	0.1	0.4	
					6	0.2	0.5		D6	19	0.3	0.6	TR6	40	0.1	0.4	
Numbers	D	0.3	1.4	18.93**	1	0.6	2.7	5.23**	D1	14	1.7	4.3	TR1	25	0.0	0.0	5.67**
	TR	0.0	0.2		2	0.0	0.2		D2	30	0.1	0.3	TR2	44	0.0	0.0	
					3	0.2	1.0		D3	46	0.4	1.3	TR3	28	0.0	0.2	
					4	0.1	0.3		D4	44	0.1	0.3	TR4	66	0.1	0.3	
					5	0.1	0.3		D5	45	0.1	0.4	TR5	42	0.1	0.2	
					6	0.1	0.3		D6	19	0.3	0.5	TR6	40	0.0	0.2	
Musical instruments	D	7.7	7.4	92.77**	1	5.5	6.8	2.53*	D1	14	8.7	7.3	TR1	25	3.6	6.0	2.07*
	TR	2.0	3.8		2	5.2	7.0		D2	30	9.7	8.3	TR2	44	2.2	3.7	

(Continues)

TABLE 3 (Continued)

Tasks	Group				Grade				Group × grade interaction								
		M	*SD*	*F* (1, 431)		*M*	*SD*	*F* (5, 431)		*N*	*M*	*SD*		*N*	*M*	*SD*	*F* (5, 431)
					3	6.4	7.9		D3	46	9.6	8.3	TR3	28	1.2	2.8	
					4	3.5	5.8		D4	44	5.8	7.4	TR4	66	1.9	3.7	
					5	4.3	5.0		D5	45	6.8	5.3	TR5	42	1.6	3.0	
					6	2.8	5.0		D6	19	5.2	6.5	TR6	40	1.7	3.7	
Miscellaneous	D	5.2	5.9	60.05**	1	3.4	5.0	2.24*	D1	14	6.5	5.1	TR1	25	1.6	4.2	0.74
	TR	1.4	3.2		2	3.2	4.9		D2	30	4.8	6.3	TR2	44	2.0	3.2	
					3	4.7	6.5		D3	46	6.3	7.3	TR3	28	2.0	3.6	
					4	3.2	4.8		D4	44	5.9	5.2	TR4	66	1.4	3.6	
					5	2.6	3.8		D5	45	4.0	4.1	TR5	42	1.1	2.6	
					6	1.4	4.3		D6	19	3.2	7.1	TR6	40	0.6	1.6	
Spatial notions	D	3.8	6.7	46.76**	1	6.3	8.9	12.31*	D1	14	11.2	10.4	TR1	25	3.5	6.6	4.98**
	TR	1.0	3.6		2	3.1	6.6		D2	30	6.9	8.5	TR2	44	0.6	2.8	
					3	3.1	5.9		D3	46	4.2	6.5	TR3	28	1.3	4.2	
					4	1.6	4.4		D4	44	2.3	4.9	TR4	66	1.2	4.0	
					5	0.8	2.6		D5	45	1.6	3.5	TR5	42	0.0	0.0	
					6	0.5	2.4		D6	19	1.2	4.1	TR6	40	0.3	0.7	
Letters[a]				*F* (1, 103)				*F* (4, 103)									*F* (4, 103)
	D	1.8	2.8	18.70**	1	1.0	2.9	2.09	D1	7	3.4	4.7	TR1	23	0.0	0.0	3.20*
	TR	0.2	0.5		2	1.4	2.7		D2	13	2.9	3.4	TR2	27	0.0	0.0	
					3	0.8	1.5		D3	13	1.5	2.0	TR3	29	0.3	0.6	
					4	0.4	0.9		D4	11	0.6	1.0	TR4	20	0.2	0.7	
					5	0.4	0.9		D5	7	0.4	1.1	TR5	14	0.3	0.8	

Note: M, mean; *SD*, standard deviation; D, dyslexics ($n = 198$); TR, typical readers ($n = 245$).

*$p \leq .01$.

**$p \leq .001$.

[a]An ANOVA test was performed for a subgroup of the sample (dyslexics $n = 51$; typical readers $n = 62$).

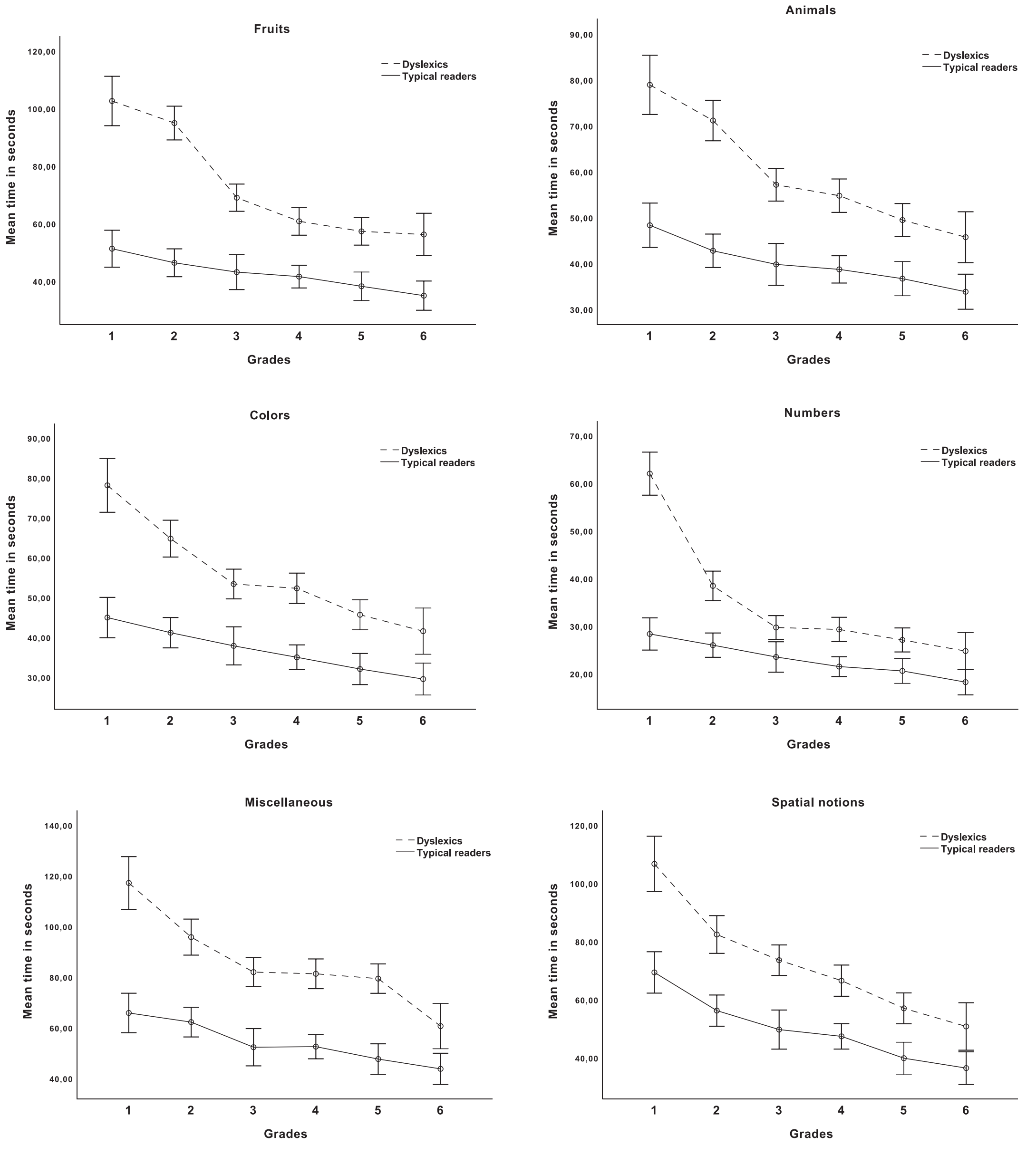

FIGURE 1 Graphical representation of the average time in seconds according to the group and grade for six of the naming tasks. Bars denote ±*SEs*

Furthermore, the naming of numbers was least related to the BDT items, while the letter naming obtained the highest correlations. Table 5 shows the correlations between the BDT and naming tasks in the dyslexic group.

4 | DISCUSSION

One of the objectives of the present study was to analyse the developmental trajectory of the accuracy and speed of naming among dyslexics and typically developing readers from the 1st to 6th grades of primary education. The

TABLE 4 Means, *SDs*, and pairwise comparisons according to the group and grade in the execution time of the naming tasks

	Dyslexics			Typical readers			
Tasks/grade	*N*	*M*	*SD*	*N*	*M*	*SD*	Pairwise comparison
Fruits							
1st grade	14	102.6	35.7	25	51.2	8.6	D1-D3***, D1-D4***, D1-D5***, D1-D6***, D2-D3***, D2-D4***, D2-D5***, D2-D6***, TR1-TR3**, TR1-TR4***, TR1-TR5***, TR1-TR6***, TR2-TR4*, TR2-TR5***, TR2-TR6***, TR3-TR6***, TR4-TR6***
2nd grade	30	94.9	35.7	44	46.3	7.2	
3rd grade	46	69.0	19.6	28	43.1	7.3	
4th grade	44	60.8	16.6	66	41.5	7.5	
5th grade	45	57.3	18.8	42	38.2	7.2	
6th grade	19	56.2	15.4	40	34.9	6.2	
Animals							
1st grade	14	78.9	25.2	25	48.2	7.7	D1-D3**, D1-D4***, D1-D5***, D1-D6***, D2-D3*, D2-D4**, D2-D5***, D2-D6*** TR1-TR2*, TR1-TR3**, TR1-TR4***, TR1-TR5***, TR1-TR6***, TR2-TR5**, TR2-TR6***, TR3-TR6*, TR4-TR6*
2nd grade	30	71.1	27.2	44	42.7	6.9	
3rd grade	46	57.1	13.7	28	39.8	4.9	
4th grade	44	54.7	11.8	66	38.7	6.7	
5th grade	45	49.4	14.7	42	36.7	6.6	
6th grade	19	45.7	9.0	40	33.8	6.3	
Colours							
1st grade	14	78.1	33.0	25	44.9	8.8	D1-D3***, D1-D4***, D1-D5***, D1-D6***, D2-D5***, D2-D6*** TR1-TR4***, TR1-TR5***, TR1-TR6***, TR2-TR4*, TR2-TR5***, TR2-TR6***, TR3-TR6**, TR4-TR6*
2nd grade	30	64.7	21.8	44	41.1	12.4	
3rd grade	46	53.3	14.7	28	37.8	8.3	
4th grade	44	52.3	15.5	66	35.0	6.0	
5th grade	45	45.6	11.1	42	32.0	6.7	
6th grade	19	41.5	10.9	40	29.5	5.7	
Numbers							
1st grade	14	62.0	33.8	25	28.3	4.6	D1-D2***, D1-D3***, D1-D4***, D1-D5***, D1-D6***, D2-D5* TR1-TR3**, TR1-TR4***, TR1-TR5***, TR1-TR6***, TR2-TR4***, TR2-TR5***, TR2-TR6***, TR3-TR6***
2nd grade	30	38.4	11.0	44	26.0	4.6	
3rd grade	46	29.7	8.2	28	23.5	4.8	
4th grade	44	29.3	7.0	66	21.5	3.4	
5th grade	45	27.1	9.6	42	20.6	3.9	
6th grade	19	24.7	6.4	40	18.2	2.7	
Musical instruments							
1st grade	14	107.0	29.5	25	73.8	15.6	D1-D3*, D1-D4*, D1-D5*, D1-D6** TR1-TR2***, TR1-TR3***, TR1-TR4***, TR1-TR5***, TR1-TR6***, TR2-TR5***, TR2-TR6***, TR3-TR6*, TR4-TR5*, TR4-TR6***
2nd grade	30	91.3	25.7	44	57.6	9.6	
3rd grade	46	77.1	22.4	28	50.2	7.3	
4th grade	44	76.6	22.6	66	51.0	10.4	
5th grade	45	76.1	30.6	42	44.0	9.2	
6th grade	19	65.2	27.3	40	41.2	9.2	
Miscellaneous							
1st grade	14	117.1	51.9	25	65.8	14.5	D1-D2*, D1-D3***, D1-D4***, D1-D5***, D1-D6***, D2-D3*,
2nd grade	30	95.7	21.0	44	62.2	13.2	
3rd grade	46	81.9	24.6	28	52.3	10.1	

TABLE 4 (Continued)

Tasks/grade	Dyslexics *N*	*M*	*SD*	Typical readers *N*	*M*	*SD*	Pairwise comparison
4th grade	44	81.2	21.3	66	52.5	10.0	D2-D4*, D2-D5**, D2-D6***, D3-D6***, D4-D6***, D5-D6**
5th grade	45	79.4	30.7	42	47.6	10.2	TR1-TR5**, TR1-TR6***,
6th grade	19	59.0	12.1	40	43.3	9.5	TR2-TR5**, TR2-TR6***
Spatial notions							
1st grade	14	106.6	33.5	25	69.3	15.5	
2nd grade	30	82.4	22.8	44	56.2	14.1	
3rd grade	46	73.5	34.3	28	49.7	10.4	
4th grade	44	66.5	15.8	66	47.3	11.3	
5th grade	45	57.0	19.4	42	39.8	7.0	
6th grade	19	50.7	11.6	40	36.4	6.0	
Letters[a]							
1st grade	7	80.4	5.8	23	28.4	3.8	D1-D2***, D1-D3***, D1-D4***, D1-D5***
2nd grade	13	51.4	4.2	27	26.2	4.1	
3rd grade	13	45.7	4.2	29	26.0	3.8	
4th grade	11	44.4	4.6	20	24.7	5.1	
5th grade	7	33.2	5.8	14	22.0	5.8	

Note: M, mean; *SD*, standard deviation; D, dyslexics ($n = 198$); TR, typical readers ($n = 245$).
*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.
[a]An ANOVA test was performed for a subgroup of the sample (dyslexics $n = 51$; typical readers $n = 62$).

findings coincide with those of other studies, since they indicate that dyslexics are slower and more inaccurate in naming task execution than readers without learning difficulties of the same age (Denckla & Rudel, 1976b; Jiménez et al., 2010; Landerl et al., 2013; Layes et al., 2016; Wolf, 1986; Żesławska-Faleńczyk & Małyszczak, 2016). However, the findings are different from those of Jiménez et al. (2010). To the best of our knowledge, it is the only study in which the naming accuracy and speed of Spanish dyslexics and typically developing readers were compared during primary education. They only found significant differences between dyslexics and typically developing readers in terms of naming speed, but not in terms of accuracy. They found no significant interaction between the group and school level for either variable. This difference in results may be due to a greater disproportion in the sample size (89 dyslexics vs. 811 typically developing readers) and the lower number of dyslexics compared to the current study (198 dyslexics vs. 245 typically developing readers). It is important to note that 'the smaller the sample size, the higher the probability of making a type II error (rejecting the research hypothesis when it is actually correct)' (Clark-Carter, 2002, p. 186). Therefore, our study provides a more representative sample of the Spanish dyslexics aged between 6 and 12 years and confirms the lack of naming accuracy and speed of these subjects, which is one of the explanatory factors of their reading difficulties.

In the present study, we observed that the performance in naming improves with age in both groups of subjects. Thus, students in their final years of primary education are significantly faster and make fewer mistakes in naming the visual stimuli of the different tasks than younger students in this educational stage. In Spanish, Rodríguez, van den Boer, Jiménez, and de Jong (2015) also showed that naming speed increases with age among 2nd to 6th-grade students (typically developing readers). Similar results can be found in other research studies that analysed the

TABLE 5 Correlations between the Bangor Dyslexia Test and the naming tasks for the group of dyslexics ($n = 45$)

	L-R	RMW	SUBT.	M-T[a]	M-F	M-B	D-F	D-B	b-d	Family
Fruits	0.13	0.20**	0.15*	−0.02	0.19**	0.14	0.18*	0.12	0.19**	0.12
Animals	0.24***	0.30***	0.25***	0.87	0.22**	0.25***	0.27***	0.29***	0.27***	0.27***
Colours	0.10	0.16*	0.12	−0.05	0.15*	0.12	0.12	0.21**	0.16*	0.07
Numbers	0.10	0.11	0.09	−0.01	0.13	0.11	0.08	0.14*	0.15*	0.12
Musical instruments	0.26***	0.27***	0.28***	0.11	0.26***	0.26***	0.28***	0.30***	0.32***	0.19**
Miscellaneous	0.18*	0.19**	0.18*	0.11	0.12	0.17*	0.17*	0.20**	0.20**	0.14
Spatial notions	0.26***	0.31***	0.22**	0.17*	0.21**	0.28***	0.26***	0.26***	0.32***	0.26***
Letters	0.40***	0.32***	0.40***	0.13	0.35***	0.41***	0.34***	0.29**	0.45***	0.41***

Note: L–R, left–right (parts of the body); RMW, repetition of multi-syllabic words; SUBT., Subtraction; M-T, Multiplication table; M-F, Months forward; M-B, Months backward; D-F, Digits forward; D-B, Digits backward; b-d, b-d confusion; Family, Family incidence.

[a]Only 31 dyslexics were included in this correlation.

*$p \leq .05$.

**$p \leq .01$.

***$p \leq .001$.

developmental trajectory of naming ability in different age groups (Albuquerque & Simões, 2010; Denckla & Rudel, 1974; Meyer, Wood, Hart, & Felton, 1998; Siddaiah et al., 2016; Van den Bos, Zijlstra, & Lutje Spelberg, 2002; Wolf & Denckla, 2005). Some authors interpreted this finding by the mutual interaction between naming speed, reading, and arithmetic practice (Meyer et al., 1998; Rodríguez et al., 2015; Van den Bos et al., 2002), especially with alphanumeric stimuli.

In general, our data suggest that the most important improvement in performance occurred in the third grade; this being more pronounced in the group of dyslexics. This finding agrees with those of other researchers who found similar progress in students who finished the 2nd and 3rd grades of primary education (Albuquerque & Simões, 2010; Meyer et al., 1998; Siddaiah et al., 2016). Jiménez et al. (2010) observed that, among Spanish 2nd to 6th grade primary education dyslexics, the greatest increase in naming speed occurs in the 5th grade, while in typically developing readers, it occurs in the 3rd grade. This difference could be due to the sample disproportion between dyslexics and typically developing readers, although we are not aware of its distribution by grade. Although our research focused on students aged between 6 and 12 years, most previous studies have indicated that naming performance continues to improve in secondary education (Siddaiah et al., 2016; Wiig et al., 2000; Wolf & Denckla, 2005). Further research on this topic is therefore necessary to understand the evolution of naming speed in both groups of subjects, since there is no consensus on the age at which a ceiling effect occurs.

Another objective of our work was to examine how familiarity with the stimulus influences the performance of the different naming tasks in both groups of participants. The obtained results illustrate that both groups made more mistakes and spent more time naming the series of miscellaneous and musical instruments, but they obtained better scores in naming the series of numbers and letters. Rodríguez et al. (2015) found similar results in the naming speed of alphanumeric and non-alphanumeric stimuli among typically developing readers. This could be interpreted in terms of the degree of familiarity with the stimuli of the series, since, as observed in this work, the total frequency of the use of the words in the miscellaneous series and musical instruments by children aged between 6 and 13 years old, is much lower than that of other series. In addition, as some authors have pointed out, the increased exposure to numbers and letters during formal teaching led to their automation (Norton & Wolf, 2012; Żesławska-Faleńczyk & Małyszczak, 2016). Pan, Yan, Laubrock, Shu, and Kliegl (2013) ascertained that naming speed was lower in more practiced stimuli, such as digits, than in less practiced stimuli, such as numerical patterns in dice, even though the naming label was the same in both cases. Another possible explanation is that alphanumeric stimuli are made up of closed categories, with a limited and precise number of labels, whereas non-alphanumeric stimuli include more ambiguous categories, with multiple names (Kirby, Georgiou, Martinussen, & Parrila, 2010).

The poor performance of dyslexics in the miscellaneous series could also be influenced by the use of different semantic fields since the presence of stimuli from the same category may facilitate the recovery of labels. Araújo, Faísca, Reis, Marques, and Petersson (2016) found that the naming time was shorter when the images were preceded by an image of the same semantic category, compared to others that were not related. In this sense, Wolf (1986) indicated that the alternation between stimuli of different categories during the naming series required both controlled and automatic attention processes, while the series with the same type of stimuli required only automatic attention processes.

Therefore, our results suggest that alphanumeric stimuli may help to better discriminate dyslexics in the initial stages of written language learning, but not so much in later stages. Moreover, the naming difficulties of dyslexics may be explained by a lack of automation in the processes of accessing the phonological code, as it is slower for low frequency words (Hanly & Vandenberg, 2010; Levelt, 2001). Nevertheless, it would be interesting to delve deeper into the effect of the type of stimulus on the execution of naming tasks according to age.

The third objective was to examine the relationship between naming speed and BDT. The analysis showed a different relationship between dyslexics and typically developing readers. In the case of the dyslexics, significant correlations were observed between all Bangor subtests and naming tasks, except for the multiplication table subtest, which was only related to spatial notions. This may be due to the small size of the sample in the dyslexic group ($n = 31$), since some of the 7- or 8-year-old children were yet to learn multiplication. Conversely, the naming of letters was the most related task, compared with the naming of numbers, which obtained the least number of significant correlations. This result was expected, since in transparent orthographies, such as Spanish, the speed of naming letters can be seen as a reflection of the degree of automaticity in the knowledge of grapheme-phoneme correspondences. Thus, it is not surprising that the highest correlations were observed between this task and the BDT, which fairly evaluated deficits associated with dyslexia. The longer it takes for dyslexics to name the letters, the worse their performance is in the execution of the BDT and vice versa. However, the naming of numbers is a more automatic task, given that its elements are practiced both in the informal context in which the child develops and in formal education. These elements are endowed with semantic content that facilitates learning. Finally, for the typically developing readers, there were hardly any significant correlations between the naming tasks and the BDT items, with the exception of the item 'months backwards' that significantly correlated with all the naming tasks, except with 'numbers' and 'letters'. Although it is difficult to establish the intersection point between the naming tasks and the BDT for the multiple components of their tests, certain common elements in most of them could be pointed out. These include verbal working memory, phonological processing, sequencing, or automation of verbal response, among others.

However, the sample used was very small (45 dyslexics and 76 typically developing readers) and further research should be conducted on the cognitive processes that are involved in both instruments and represent a deficit in dyslexic subjects. Their aim should be to improve detection and early evaluation of children who are at risk of suffering reading difficulties and design intervention programmes adapted to their difficulties.

The small sample size is one of the main limitations of the study. However, given the characteristics of the population to study, it was difficult to find participants for data collection. Another limitation of our study was the lack of previous research on any of the objectives of the study, which made it difficult to discuss the results. Despite these limitations, this study significantly contributes to the existing literature. First, we covered the developmental trajectory, from 6 to 12 years old (the entire primary education stage) in terms of naming accuracy and speed in a wide range of RAN tasks in Spanish. This differs from the work of Jiménez et al. (2010) and Rodríguez et al. (2015), who covered grades 2 to 6 of this educational stage (from 7 to 12 years old). Second, we noted that the type of stimulus is a factor in assessing the naming difficulties of dyslexics according to age. Finally, we found that serial naming may be related to deficits associated with dyslexia other than reading.

DATA AVAILABILITY STATEMENT

Research data are not shared

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