Title: Naming Speed as a Predictive Diagnostic Measure in Reading and Attentional Problems

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Acknowledgments

This work was supported by the Region Government of Asturias; under Grant [FC-15-GRUPIN14-053]; and a pre-doctoral grant from the Severo Ochoa Program; under Grant [BP14-030]. We would like to thank Dr Stephen Loew for his contribution in the areas of language and style corrections.

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Abstract.

This study aimed to describe and compare naming speed abilities in children diagnosed with either Reading Learning Difficulties (RLD) or Attention Deficit/Hyperactivity Disorder (ADHD), or comorbidity for both (ADHD+RLD). To examine the explanatory power of naming speed and ADHD symptomatology in predicting group-associations (while controlling for gender and age) the 'Rapid Automatized Naming and Rapid Alternating Stimulus Tests' (RAN/RAS) were utilized. A sample of 101 children (age range = 5-16 years) was divided into four groups: RLD (n = 14), ADHD (n = 28) Comorbid (n = 19), and Control (n = 40). There were statistically significant differences in RAN/RAS results among the diagnostic groups. Moreover, discriminant analysis revealed that naming speed tasks significantly predicted reading and attentional problems, especially at earlier ages. These results demonstrate the potential usefulness of RAN/RAS in the diagnosis of reading and attentional problems, particularly if the children are aged from 5 to 9.

Key words: RAN/RAS, naming speed, reading difficulties, ADHD, early childhood.

1. Introduction

Naming speed tasks are defined as the ability to name -as quickly as possible- different familiar stimuli such us: numbers, letters, colors and figures (Georgiu, Aro, Liao, & Parrila, 2016). As in cases of phonological deficits in children with Reading Learning Difficulties (RLD), a naming speed deficit frequently persists from early school age to adulthood (Van den Bos, 1998).

Current research has highlighted that naming speed can predict reading accuracy and fluency, and several authors have thereby shown the relationship between naming speed and word and/or pseudoword reading or math/spelling difficulties (Donker, Kroesbergen, Slot, Van Viersen, & De Bree, 2016; Georgiou, Parrila, Cui, & Papadopoulos, 2013; Mazzocco & Grimm, 2013). Likewise, other studies have demonstrated the existence of a strong relationship between naming speed and reading comprehension, as well as its relationship with reading speed (Wolf, 2014). In this sense, it has been argued that children with RLD show significantly slower naming speed rates than children without RLD. More specifically, children with RLD have been found to display greater difficulties when the naming speed tasks are exclusively based on letters and numbers (Clikeman, Guy, & Griffin, 2000; Chang et al., 2014; Mazzocco & Grimm, 2013). These studies were designed to investigate the hypothesis of a *processing speed deficit*, which states that children with RLD are unable to reach the necessary speed to capture letter patterns that are present in written language (Bowers & Newby-Clark, 2002).

In the same way, word naming has also been investigated extensively in ADHD, and most results have indicated impairments in both children and adults with the disorder (Laasonen, Lehtinen, Leppämäki, Tani, & Hokkanen, 2010), however, children appear to have more difficulties than adults do (Frazier, Youngstrom, Glutting, & Watkins, 2007). Using the RAN/RAS test, many authors have shown how children with ADHD present lower performances in naming speed tasks, specifically in those composed of figures and colors (Clikeman et al., 2000; Hinshaw, Carte, Fan, Jassy, & Owens, 2007; Roessner, et al., 2008). These naming speed impairments in subjects with ADHD are perhaps expectable, as successful performance in these sorts of tasks requires processes involving attention to the stimuli, as well as switching and disengaging attention under certain circumstances (e.g. alternating stimuli tasks); and would thus be most affected by inattention rather than impulsivity/hyperactivity symptoms (Norton & Wolf, 2012). Despite all of these findings, the predictive value of naming speed tasks in the diagnosis of ADHD has not been examined to date.

In general terms, the research described above has shown that naming speed is an efficient predictor of reading problems, and could thus also be predictive of attentional impairment, depending on the type of stimuli considered (Chang et al., 2014; Clikeman et al., 2000; Mazzocco & Grimm, 2013).

This is important, given the practical relevance of analyzing and delimiting execution-performance profiles in children with ADHD and RLD, especially considering the high comorbidity of both disorders (García et al., 2013; González-Castro, Rodríguez, Cueli, García, & Álvarez, 2015). According to Zamora, López & Gómez (2009), the percentage of comorbidity of ADHD and RLD ranges from 8 to 39%. Rodríguez et al. (2009), as well as García et al (2013), have also argued that the comorbidity of ADHD and RLD is related to the presence of a common deficit in the executive functions system, such as impairments in working memory, inhibitory control and processing speed.

The majority of these studies have followed the technique of de Denckla and Rudel (1976), using the *Rapid Automatized Naming and Rapid Alternating Stimulus Tests* (RAN/RAS) (Norton et al., 2014; Norton & Wolf, 2012; Wolf & Denckla, 2005). This test comprises four primary naming speed tasks, in which all visual stimuli displayed are exclusively letters, numbers, colors and figures; and two additional naming tasks composed of visual stimuli presented randomly and alternately (2-SET: letters and numbers; and 3-SET: letters, numbers and colors). For each naming task, the child is asked to name (as quickly as possible) the different stimuli that compose the naming matrix. The administration of the whole test takes from 5 to 10 minutes, depending on the child´s age, reading skills and language fluency (i.e. first or second language).

Performance of RAN/RAS tests requires several processes that are interconnected (Wolf & Denckla, 2005), such as attentional and visual processes, the integration of visual patterns and orthographic information, and the recovery of phonological labels. Frequently, these processes are impaired in ADHD and/or RLD children (González-Castro, Rodríguez, López, Cueli, & Álvarez, 2013) and this impairment is manifested through a greater decrease in naming speed ability. There is an extensive body of research (Georgiou, Papadopoulos, & Kaizer, 2014; Norton & wolf, 2012; Tan, Spinks, Eden, Perfetti, & Siok, 2005) that has led us and other researchers to consider RAN tasks as being one of the best and most internationally-valid predictors of reading fluency, perhaps universally across all known orthographies. Several authors have previously highlighted the usefulness of RAN/RAS tests concerning the early detection of attentional and reading problems, because (in contrast with other tests), these tests provide an early indicator of vital reading and attention skills well before children are able to read and write efficiently (Areces, Rodríguez, González-Castro, García, & Cueli, 2017). In particular, the alphanumeric nature of the RAN test (tasks composed of letters or numbers) has been more closely associated with reading abilities (Pham, Fine, & Clikeman, 2011), while the non-alphanumeric RAN test (tasks composed of colors or objects) has been more associated with attentional processes (Kieling et al., 2010; Roessner et al., 2008). Thus, lower naming speed scores in the non-alphanumeric component of the RAN (common in subjects with attentional difficulties) are most likely due to the existence of more than one plausible name for a given object or color, thereby producing a greater demand on attention and the need for more careful and detailed processing than that required for recognizing letters or digits (Tannock, Banaschewski, & Gold, 2006). In other words, letters and numbers engage largely automated decoding processes, whereas objects and colors do not, and as such, the latter consume-more resources relating to attention.

However, despite the large amount of evidence suggesting the diagnostic usefulness of this measure in identifying reading and attentional problems, very few studies have been carried out with Spanish speakers. This highlights the need for additional studies in the Spanish population, because it is important to answer the following questions: 1) Do children perform differently in RAN/RAS as a function of their attentional and reading problems? 2) Are naming tasks effective for detecting reading and attentional problems? 3) Is the discriminant capacity of RAN/RAS test the same in different age groups?

These critical questions gave rise to the impetus to carry out the present study, which was designed in the context of the following objectives and hypotheses.

This study has two main objectives: 1) to describe and compare the naming speed in a sample composed of children and adolescents RLD, with and without ADHD, using the variables provided by RAN/RAS test; and 2) to examine the explanatory power of naming speed and ADHD symptomatology (provided by EDAH scale, completed by the families, Farré & Narbona, 2001) to predict group association, controlling for the potential effect of gender and age.

Based on previous research (Clikeman Guy, & Griffin, 2000; Roessner et al., 2008) it was expected that children with ADHD and RLD will obtain lower scores in naming speed than the control group. According to the second objective, as different studies confirm, the amount of time invested by participants on naming different types of stimuli have a strong correlation with reading skills and attentional processes. In this sense, several authors argued that, although the RAN/RAS test represents a high-quality measure for detecting children with Reading Difficulties and attentional problems, its diagnostic capacity decreases with age, due to the automation of attentional and reading processes (Elosúa et al., 2012). Accordingly, as age increases, the difficulty levels of the naming tasks are likely to become lower. Therefore, the effectiveness of RAN/RAS might decrease with age, and professionals may need to use other specific diagnostic tools, such as those based exclusively on DSM criteria (APA, 2013).

Concerning the predictive value of RAN/RAS, cross-cultural research has shown that this test is predictive of reading outcomes across a variety of languages including Dutch (Van den Bos, 1998), German (Wimmer, 1993), Hebrew (e.g., Bental & Tirosh, 2007), French (e.g., Plaza & Cohen, 2004), or Greek (Georgiou, Papadopoulos, & Kaizer, 2014; Papadopoulos, Spanoudis, & Georgiou, 2016). Thus, a statistically significant predictive value of the test detecting reading difficulties is expected to be found in the present study. In the same way, given that RAN/RAS tasks rely on continuous responding, and children must pay attention in order to perform well and quickly execute the tasks, it is therefore reasonable to question whether RAN/RAS is also predictive of attentional problems. This is particularly relevant considering the high comorbidity between LRD and ADHD (García et al., 2013; González-Castro et al., 2015).

2. Material and Methods

2.1. Participants

This study used a non-probabilistic clinical sample of 101 participants, 64 males (63.4%) and 37 females (36.6%), between 5 to 16 years of age (*M* = 10.10; *DT* = 3.15).

Average IQ of the sample was 97.40 (*SD* = 11.58). The Wechsler Intelligence Scale for Children–IV s (WISC-IV; Wechsler, 2005) was used to measure intellectual ability. Participants showing extreme IQ values (lower than 80 and greater than 130) were excluded from the sample. Only one student was excluded from the study on this basis, because of having an IQ below 80.

The participants in the ADHD and RLD groups were identified according to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; APA, 2013), resulting in four groups: Control group (n = 40, 39.6%), RLD group (n = 14, 13.9%), ADHD group (n = 28, 27.7%), and Comorbid group of ADHD and RLD (n = 19; 18.8%). None of the participants with ADHD were receiving medication at the time of assessment (Table 1).

Table 1 about here

No statistically significant differences were found among the groups with respect to IQ (p = .472), although some differences in age were highlighted, F(3, 100)= 3,287*;* p = .024*;* η^2 = .092.

2.2. Instruments

The Wechsler Intelligence Scale for Children-IV (WISC-IV) (Wechsler, 2005) was used to evaluate IQ. Those individuals with IQs below 80 or over 130 were excluded from the sample. WISC-IV is an individually administered test composed of 15 subtests which provide information on specific cognitive areas. It can be administered to children and adolescents between 6 and 16 years. In this study, only the Total Intelligence Quotient (TIQ) was considered.

As mentioned earlier, *Rapid Automatized Naming and Rapid Alternating Stimulus Tests* -RAN/RAS- (Wolf & Denckla, 2005) were used to evaluate naming speed. This is a test of naming speed that reflects the relationship between processing speed and reading speed. The test consists of four naming tests with different single stimulus type (letters, numbers, colors, objects) and two naming tests with alternating stimuli (letters-numbers, letters-numbers-colors). The scores in each task are based solely on the time taken (in seconds) to name each one of the six stimuli matrices.

In order to determine the relevance of ADHD symptoms in the diagnosis of ADHD (with or without RLD), *The Scale for the assessment of Attention Deficit Hyperactivity Disorder* (EDAH) (Farré & Narbona, 2001) was utilized (as per: *EDAH - version for families*). It consists of 20 items that provide information on the presence of symptoms related to attention deficit and hyperactivity/impulsivity. It differentiates between ADHD and control groups, as well as between the primary ADHD subtypes. The following variables were included in the present study: EDAH-AD (score in the items that measure Attention Deficit), EDAH-I/H (score in Impulsivity/Hyperactivity items), and EDAH-ADHD (score in the combined subtype; Attention Deficit plus Impulsivity/Hyperactivity symptoms).

2.3. Procedure

The sample was recruited from a psychotherapeutic center attended by children diagnosed with RLD and/or ADHD. They were identified by government-registered mental-health professionals (typically psychologists) as per guidelines in the DSM-5 criteria for ADHD and Reading Learning Difficulties (DSM-5: American Psychiatric

Association, 2013). The schools attended by the participants were in urban and semi-urban zones from a region in the north-west of Spain.

The control sample was recruited from the same schools to serve as a control healthy comparison group. Participants were included in the control group if they had no reported history of serious behavioral or emotional problems in school or at home and also no reported history of reading and attentional problems.

The study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki), which reflects the ethical principles for research involving humans (Williams, 2008) and was approval by the Ethics Committee. All subjects and their parents gave written informed consent after receiving a comprehensive description of the study protocol. Participants had voluntarily agreed to be involved in this study and they were not given any monetary or school-based incentives to take part in it. To that end, once parental consent to evaluate the children was provided, the study's corresponding tests were administered in order to verify the objectives of this research.

2.4. *Data analysis*

This study analyzed the differences in naming speed between four diagnostic groups (Control;,ADHD; RLD; ADHD+RLD), and examined the discriminant value of naming speed and attentional symptoms provided by the EDAH scale in predicting group-association. To accomplish this, all data analyses were conducted in three steps:

First, the descriptive statistics for the variables under study were analyzed, paying special attention to skewness and kurtosis. Following the criterion of Kline (2011), the maximum scores accepted for skewness and kurtosis were limited to a range of 3 to 10. The majority of the variables measured in the present study met this criterion, with some exceptions regarding time invested (in seconds) for naming numbers within the ADHD groups. The results thus allowed us to perform parametric analyses.

Second, multivariate analysis of covariance (MANCOVA) were performed to analyze differences in naming speed between the four diagnostic groups, taking into account the type of stimuli (figures, colors, letters and numbers) as dependent variables, and using age as a covariate. Cohen´s (1988) delta was used as a measure of effect size. The author defines a small effect size as $\eta 2 = .010$ (Cohen's d = .20), a medium effect size as $\eta 2 = .059$ (Cohen's d = .50), and a large effect size as $\eta 2 = .138$ (Cohen's d = .80). Scheffé multiple comparisons were used to determine statistically significant differences between pairs of groups. These analyses assumed the previous step of the discriminant analysis.

Third, once the existence of statistically significant differences between the groups was verified, different discriminant analyses were conducted to determine the relevance of each dependent variable (naming speed variables by RAN/RAS and attentional symptoms by EDAH) to predict group association, taking age-group into account (group 1: age range 5-9, and group 2: age range 10-16). Four discriminant analyses were performed: two of the procedures were to test the relevance of the studied variables predicting RLD group membership (a discriminant analysis was conducted for each age group), and the other two were to examine the reliability of the aforementioned variables in predicting ADHD group membership (two different analyses for each age group).

SPSS 19 (Arbuckle, 2010) was used in the analysis of data, utilizing $p < .05$ as the criterion for reaching statistical significance. Bonferroni protection was used for the interpretation of *p* values in multiple comparisons ($p < .05/6 = .008$).

3. Results

3.1. Differences between groups in naming speed

Table 2 shows the descriptive statistics for each RAN measure. Results from the MANCOVA, taking into account age, λ = 0.430, $F(3, 100) = 1.948$, $p \leq .001$, $\eta^2 = .470$ and IQ *(p = .378)* as covariates, showed that there were statistically significant differences between the groups, λ = 0.705, $F(18, 249) = 1.826$, $p = .023$, $\eta^2 = .110$ in the studied variables. At this point, it is worth noting that high scores in the RAN/RAS test are indicative of high response times, which are related to poor performance in the naming tasks.

Table 2 about here

On the other hand, inter-subject effects demonstrated the presence of statistically significant differences between groups in each of the naming tasks, with the exception of the number naming task: objects, $F(1, 98) = 3.174$, $p = .028$; $\eta^2 = .093$; colors, $F(1, 98) = 5.664$, $p = .001$; $\eta^2 = .154$; numbers, $F(1, 98) = 1.777$. $p = .157$, $\eta^2 = .054$; letters, $F(1, 98) = 2.696$, $p = .05$, $\eta^2 = .080$; letter and numbers $F(1, 98) = 3.176$, $p = .028$, $\eta^2 = .093$;and letters, numbers and colors, $F(1, 98) = 3.297$, $p = .024$, $\eta^2 = .096$.

Post hoc analyses (Table 3) revealed significant group differences with Bonferroni protection (p<05/6=.008) that the total score in some of the naming tasks generated differences between the Control group and the Comorbid group (ADHD+RLD). By contrast, the color naming task generated differences between the Control group and the RLD group.

Table 3 about here

3.2. Discriminant value of RAN/RAS and attentional variables in the diagnosis of RLD and ADHD

Given that one of the objectives of the present study was to analyze the diagnostic relevance of RAN/RAS and attentional variables to predict group membership (presence or absence of ADHD and RLD), and considering the importance of age in the RLD and ADHD diagnosis, the total sample was divided into two age-groups (Table 4).

The first group was made up 52 participants, 27 males (51.9%) and 25 females (48.1%), from 5 to 9 years of age (*M* = 7.42; *SD* = 1.29) divided into the four diagnostic groups. Average IQ for this group was 98.21 (*SD* = 11.96). No statistically significant differences were found between groups in IQ (p = .583) and age (p = .429).

The second group was composed of 59 participants, 37 males (75.5%) and 12 females (24.5%), from 10 to 16 years of age (*M* = 12.94; *SD* = 1.70), with an average IQ of 99.31 (*SD* = 11.25). As with the first group (described above), no statistically significant differences were found between groups in IQ (p = .581) and age (p = .451)

Table 4 about here

Tables 5 and 6 show results from the discriminant analyses, with the objective of examining the explanatory power of naming speed in predicting group membership (RLD vs. Control group, and ADHD vs Control group). To this end, naming speed variables provided by RAN/RAS test were used (i.e. scores obtained in naming objects, colors, numbers and letters). The attentional variables obtained by the EDAH scale were also included as potential predictors of group membership, along with age and gender. Accordingly, the *Standardized* coefficients represent the correlations between the discriminant function and the variables (revealing the most influential variable in each case), and the *Function* coefficients provide the resulting discriminant function.

Table 5 shows the results of discriminant analyses for the diagnostic groups with and without RLD. The resultant data showed that only the score obtained in naming colors (RAN7RAS) was a statistically significant predictor of group membership, both for the group aged from 5 to 9 years, and for the group aged from 10 to 16 years. In the younger group (5 to 9 years of age), this model classified 78% of the sample correctly (83.3% from the Control group, and 73.9% from the RLD group). On the other hand, for the older group, this model classified 77.4% of the sample correctly (90.50% from the Control group, and 50% from the RLD group).

Table 5 about here

Table 6 shows the results of discriminant analyses for the diagnostic groups with and without ADHD. Conversely to the previous case, some differences between the age-groups were found. In relation to the younger group (5 to 9 years of age), only the score obtained in naming colors through RAN/RAS test and the inattention symptoms from EDAH were statistically significant predictors of group membership. This model classified 84.1% of the sample correctly (64.7% from the control group, and 96.3% from the ADHD group). On the other hand, for the older group, the results from discriminant analyses indicated that the RAN/RAS variables did not show explanatory power for predicting group membership, and only inattention, impulsive and hyperactivity symptoms were statistically significant predictors. Specifically, this model classified 76.9% of the sample correctly (83.3% from the control group, and 71.4% from the ADHD group).

Table 6 about here

4. Discussion and conclusions

This study aimed to (1) analyze performance differences in RAN/RAS tasks in four diagnostic groups (Control group, RLD group, ADHD group, and RLD+ADHD group), and (2) verify the explanatory power of RAN/RAS variables and ADHD symptoms by EDAH scale to predict the diagnosis of ADHD and/or RLD in two different age groups.

Regarding the first objective, results showed that children and adolescents with Reading Difficulties (with or without ADHD association) obtained lower performance in RAN/RAS tasks than the Control group (Chang et al., 2014; Clikeman, Guy, & Griffin, 2000; Donker, Kroesbergen, Slot, Van Viersen, & De Bree, 2016). In addition, the present research has shown that the naming tasks consisting of colors and alternating stimuli (letter-numbers and letters-numbers-colors) were effective in identifying Reading Difficulties. These findings showed some differences with previous studies which had highlighted that alphanumeric RAN (tasks composed of letters or numbers) has been associated with reading (Pham, Fine, & Clikeman, 2011), while the non-alphanumeric RAN (tasks composed of colors or objects) has been related to attentional processes (Kieling et al., 2010; Roessner et al., 2008). These differences can be explained by two key factors. The first of these may well be related to differences in the transparency of the languages, since the majority of previous studies have been carried out in opaque languages like English (Areces et al., 2017). With respect to the second factor, these results could be also explained by the fact that, although the majority of children are used to naming letters and numbers (due to school training), they are not so familiar with naming tasks consisting of colors or randomly alternating stimuli. In this sense, and because these tasks are not automated processes, the children who belonged to the control group manifested a slight decrease in naming speed, while the children with reading and attentional problems experienced a larger and more significant impairment in these sorts of tasks (Tannock, Banaschewski, & Gold, 2006).

Concerning ADHD performance in RAN/RAS tasks, similar results to previous English-based studies (Clikeman Guy, & Griffin, 2000; Roessner et al., 2008) were observed, in that children with ADHD obtained worse scores in naming tasks that were based on figures and colors exclusively. In this sense, and as previous studies have noted, rapid naming speed tasks have been shown to be an important component of discriminant function analysis batteries for distinguishing ADHD and non-ADHD groups (Carte, Nigg, & Hinshaw, 1996; Tannock, Martinussen, & Frijters, 2000).

On the other hand, it is worth noting that when the total sample was considered, the results indicated that the symptomatology of ADHD and RLD appear to interact with each other, as the comorbid group (ADHD+RLD) showed a distinct profile regarding the performance of naming tasks. These results are also coherent with the findings of previous studies that have found greater consequences and difficulties in the comorbid group (Rodríguez et al., 2009; García et al., 2013). However, these additional difficulties cannot be simply explained by the additive effects of ADHD and RLD symptomatology.

Likewise, in relation to the second objective, analysis of how naming speed and ADHD symptoms (based on DSM criteria) might predict group classification (e.g. ADHD, RLD, or Control), the results showed that the RAN/RAS test is more effective in the detection of RLD (with or without ADHD) at early ages (specifically, from 5 to 9 years) (Clikeman, Guy, & Griffin, 2000; Mazzocco & Grimm, 2013). This could be explained by the fact that above 10 years of age, the difficulty level of naming tasks is lower, thus all diagnostics groups will show better performance. Conversely, under 10 years of age, when children still do not have fully-automated reading skills, they will have more difficulty with naming tasks by RAN/RAS test (particularly, the children with attentional and reading problems) (Elosúa et al., 2012). In the same line, there are several studies which have found significant differences in the performance of RAN/RAS tasks composed of colors and letters between samples of children with and without learning difficulties, when they are under 10 years of age (Dos Santos, De Lima, & Ciasca, 2016).

Similarly, the present study also verifies that RAN/RAS tasks can be effective measures in the diagnosis of ADHD, but only when children are under 10 years of age.

In this sense, as children get older, the clinical effectiveness of DSM criteria (APA, 2013) which are contained in several observation scales (including the EDAH scale), become better predictors of diagnosis than performance in naming tasks. Accordingly, once the possible presence of ADHD is detected by means of the RAN/RAS test, the clinician would need to carry out an exhaustive and comprehensive assessment based on the performance and diagnostic criteria in established clinical guides and manuals.

In general terms, taking into account the results obtained in this study, it is possible to affirm that RAN/RAS test is more effective in the detection of reading and attentional problems at early ages. From the age of 10 onwards, there are hardly any differences between groups.

4.1. Limitations of the present study

Finally, it is important to highlight some limitations of the present study that should be considered in future research. The main limitation is related to the composition of the groups. Specifically, it would be interesting to divide the RLD group according to the affected reading route (lexical, phonological or both routes). This differentiation would allow researchers to know whether RAN/RAS test is equally effective depending on the affected reading route. Likewise, it would be also interesting to differentiate the ADHD group with regard to the type of presentation (predominantly inattentive, predominantly impulsive and hyperactive and combined presentation) in order to verify the diagnostic specificity of the RAN/RAS test to a greater extent. In addition, sample size must be expanded in order to better determine whether the discriminative capacities of the measures used in the present study are similar to those of the measures used in previous studies. Lastly, it would be interesting to combine RAN/RAS measures with other diagnostic systems that are now providing important insights into the processes involved in reading and attentional control tasks, such as eye-tracking techniques (e.g. Al Dahhan et al., 2014; Kuperman, Van Dyke, & Henry, 2016).

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Table 1

Descriptive statistics of IQ and Age for the four diagnostic groups

Groups		IQ		Age	
	n	*M*	*SD*	*M*	*SD*
CG	40	99.03	10.25	10.88	3.11
RLD	14	99.50	6.83	9.79	3.22
ADHD	28	100.43	14.26	10.54	3.14
ADHD+RLD	19	95.11	12.63	8.05	2.39
Total Sample	101	98.74	11.58	10.10	3.15

Notes: *M* = Mean; *SD*= Standard Desviation. CG = Control group; RLD = Reading Learning Difficulties; ADHD = Attention Deficit and Hyperactivity Disorder; ADHD+RLD = Attention Deficit and Hyperactivity Disorde with Reading Learning Difficulties.

Table 2.

Descriptive statistics of the RAN/RAS tasks for the diagnostic groups.

Groups	RAN tasks	*M*	*SD*	Skewness	Kurtosis
CG	Objects	41.13	10.788	.459	-0.520
(*n* = 40)	Colors	40.46	9.660	.313	-0.674
	Numbers	25.79	11.200	4.031	20.974
	Letters	26.62	7.859	.446	-0.791
	LN	28.90	8.042	.082	-1.021
	LNC	31.54	11.206	1.548	4.767
RLD	Objects	54.93	20.938	1.296	0.853
(*n* = 14)	Colors	70.36	44.597	1.560	1.186
	Numbers	42.00	34.122	2.819	9.013
	Letters	46.00	42.486	2.855	9.107
	LN	53.21	49.465	2.776	8.619
	LNC	55.36	44.370	2.130	4.469
ADHD	Objects	50.86	23.095	1.173	0.358
(*n* = 28)	Colors	52.89	26.880	1.565	2.008
	Numbers	31.04	21.781	3.508	13.905
	Letters	30.43	18.420	2.486	7.377
	LN	37.93	26.084	2.577	7.512
	LNC	40.85	28.090	2.527	7.708
ADHD+RLD	Objects	58.79	20.203	2.404	8.138
(*n* = 19)	Colors	67.11	24.177	1.575	3.261

	Numbers	44.42	23.784	1.576	1.812
	Letters	48.84	28.683	1.749	3.492
	LN	58.47	32.509	1.491	2.581
	LNC	61.00	30.894	1.177	1.969

Notes: *M* = Mean; *SD* = Standard Desviation; CG = Control group; RLD = Reading Learning Difficulties; ADHD = Attention Deficit and Hyperactivity Disorder; ADHD+RLD = Attention Deficit and Hyperactivity Disorder with Reading Learning Difficulties.

Table 3

Scheffé Multiple Comparison for the four groups

RAN/RAS Tasks	RLD vs. CG		ADHD vs. CG		ADHD+RLD vs. CG		RLD vs. ADHD		ADHD+RLD vs. RLD		ADHD+RLD vs. ADHD	
	MD	*d*	*MD*	*d*	*MD*	*d*	*MD*	*d*	*MD*	*d*	*MD*	*d*
Objects	13.80	1	10.32	0.61	17.66	1.24	3.48	0.11	3.86	0.19	7.35	0.34
Colors	29.90***	1.28	12.38	0.69	26.64***	1.72	17.06	0.52	-3.25	0.1	13.81	0.54
Numbers	16.21	0.84	5.65	0.35	18.36	1.17	10.56	0.41	2.42	0.09	12.98	0.58
Letters	19.38	0.89	4.24	0.32	22.23**	1.3	15.15	0.54	2.84	0.08	17.99	0.79
LN	24.32	0.96	9.73	0.55	29.58***	1.55	14.58	0.42	5.26	0.13	19.84	0.70
LNC	23.82	1	9.31	0.47	29.46***	1.52	14.51	0.43	5.64	0.16	20.15	0.70

Notes: *MD*= Mean Differences; *d*= cohen's d effect size; LN= Letters and Numbers; LNC= Letters, Numbers and Colors; CG = Control group; RLD = Reading Learning Difficulties; ADHD = Attention Deficit and Hyperactivity Disorder; ADHD+RLD = Attention Deficit and Hyperactivity Disorder with Reading Learning Difficulties.

* ** significant with Bonferroni protection ($p < .05/6 = .008$).

Table 4

Descriptive statistics for IQ and age in function of the aged group.

	Group aged 5-9 years					Group aged 10-16 years				
Groups		IQ		age			IQ		age	
	n	*M*	*SD*	*M*	*SD*	n	*M*	*SD*	*M*	*SD*
CG	18	99.33	10.79	7.84	.942	22	98.77	10.03	13.36	1.67
RLD	7	102.43	4.12	7.14	1.46	7	96.57	7.99	12.43	1.98
ADHD	11	98.00	14.84	7.18	1.54	17	102.00	14.11	12.71	1.57
ADHD+RLD	16	95.25	13.49	7.25	1.39	3	94.33	8.38	12.33	2.08
Total sample	52	98.21	11.96	7.42	1.29	49	99.31	11.25	12.94	1.70

Notes: M = Mean; SD = Standard Desviation; CG = Control group; RLD = Reading Learning Difficulties; ADHD = Attention Deficit and Hyperactivity Disorder; ADHD+RLD = Attention Deficit and Hyperactivity Disorder with Reading Learning Difficulties.

Table 5

Results of discriminant analyses for predicting RLD group membership, using stepwise method. Analyses with RAN/RAS variables and ADHD symptoms for age conditions.

	Standardized Coefficients	Function Coefficients	*F*
	RAN/RAS test from 5 to 9 years of age		
Raw.Col	1.000	.036	12.830
Constant		-2.341	
	RAN/RAS test from 10 to 16 year of age		
Raw.Col	1.000	.124	10.171
Constant		-4.784	

Notes: Raw.Col= score obtained in naming colors.

All models are significant at a $p < .001$ level. Only the variables that resulted statistically significant are shown.

Table 6

Results of discriminant analyses for predicting ADHD group membership, using stepwise method. Analyses with RAN/RAS variables and ADHD symptoms for age conditions.

	Standardized Coefficients	Function Coefficients	*F*
	RAN/RAS test from 5 to 9 years of age		
Raw.Col	.609	.040	16.350
EDAH.AD	.769	.037	12.685
Constant		-5.810	
	RAN/RAS test from 10 to 16 year of age		
EDAH.AD	.606	.045	13.548
EDAH.I/H	.922	.049	10.187
Constant		-7.677	

Notes: Raw.Col= score obtained in naming colors; EDAH.AD = attention deficit symptoms in EDAH test; EDAH.I/H = impulsivity/ hyperactivity symptoms in EDAH test.

All models are significant at a $p < .001$ level. Only the variables that resulted statistically significant are shown.