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Article

Reading fluency in children: which are the underlying abilities?

Fluidez lectora en niños: cuáles son las habilidades subyacentes

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Abstract

Reading fluency is an important component of reading learning process and reading comprehension. Fluency in reading is a construct that involves reading accuracy, expressive reading, speed and reading comprehension. In Spanish there are few tools to assess it so, the aim of this work is to stablish which are the underlying skills of reading fluency in order to obtain information for the future design of a test that evaluates it with texts in Spanish. A group of 172 primary school children from third, fifth and seventh grades with no reading learning disabilities were evaluated. The participants were assessed with five tasks: phonological fluency (FVF), phonological awareness (CF), naming (RAN), word and nonword reading (Lectura de PyNP) and text reading aloud (LVA) from which reading accuracy, speed and comprehension measures were extracted. The results obtained provide information about variables that affect directly (RAN and reading of PyNP) and indirect (CF and FVF) on reading fluency. These data are relevant for the forthcoming design of a battery that allows professionals how to measure this construct.

Resumen

La fluidez lectora es un componente crítico del aprendizaje de la lectura y la comprensión de textos. En español son escasas las herramientas para evaluar este constructo que involucra aspectos relativos a la precisión lectora, la expresividad, la velocidad y la comprensión. A fin de obtener información para el futuro diseño de una batería que evalúe la fluidez a partir de textos en español, este trabajo se propone establecer las habilidades subyacentes a la fluidez. Para tal fin, se evaluó a un total de 172 niños de 3º, 5º y 7º curso de Educación Primaria sin dificultades para el aprendizaje de la lectura. Los participantes respondieron cinco tareas: fluidez verbal fonológica (FVF), conciencia fonológica (CF), velocidad de denominación (RAN), lectura de palabras y no palabras (Lectura de PyNP) y lectura en voz alta de un texto (LVA), a partir de la cual se extrajeron medidas de precisión lectora, velocidad y comprensión. Los resultados obtenidos brindan información sobre variables que inciden de manera directa (RAN y Lectura de PyNP) e indirecta (CF y FVF) sobre la fluidez lectora. Estos datos resultan relevantes para el futuro diseño de una batería que permita medir este constructo.

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Introduction

In the last few years, the works on reading performed started to analyse aspects related to reading fluency, because it is a critical component of the reading learning process and it is an essential aspect of reading literacy (Gómez Zapata, Defior & Serrano, 2011; Hudson, 2011; Hudson, Lane & Pullen, 2005; Paige, Rasinski, Magpuri-Lavell & Smith, 2014; Rasinski, 2010; Rasinski et al., 2017).

What is reading fluency about? Certain researchers (Hudson, 2011; Hudson et al., 2005; National Reading Panel, 2000) define it as correct, expressive reading of a coherent, cohesive text at a speaking pace comparable to that of a conversation. Other authors (Samuels, 2002, 2006; Samuels, Schermer & Reinking, 1992), also include text comprehension in its definition as a relevant parameter. In general terms, reading fluency is a measurement obtained from the number of words in isolation or in a certain context that are read correctly in one minute (Torgesen, Rashotte & Alexander, 2001).

At least two processes can be identified to characterise reading fluency. On one hand, the identification processes of words or decoding (Berninger et al., 2010; Ehri, 2002, 2005; Samuels, 2006) and, on the other, comprehension or constructing the text's meaning (Rasinski, 2010; Rasinski, Rikli & Johnston, 2009; Young, Mohr & Rasinski, 2015). In order for reading to be successful, readers cannot allocate the same amount of resources to both processes. Fluent readers can read words without making any mistakes and without effort and the sentences' limits can be duly perceived when they read out loud. These reading characteristics evidence that the cognitive resources are being administered efficiently (LaBerge & Samuels, 1974). The decoding processes are automatised and require less resources, most of which are allocated to construct a representation of the text's meaning, the ultimate goal of reading (Schwanenflugel, Fletcher, Francis, Carlson & Foorman, 2004; Perfetti & Stafura, 2014).

The automation of decoding processes is based on various underlying skills that, on the basis of their evaluation, allow for those readers with difficulties to be detected. In order to become an efficient reader in an alphabetical orthographic system as that of the Spanish language, it is essential to acquire appropriate decoding skills (Adams, 1992; Anthony et al., 2010; Ehri, 2014; Ouellette & Van Daal, 2017; Serrano & Defior, 2008); which means that children must have command on the grapheme-phoneme conversion rules and that they must automatise the decoding systems in order to store orthographic representations of words in their mental lexicon (Ehri & McCormick, 1998). These mechanisms enable them to read correctly and effortlessly words that are both known and unknown to them. In this process, *Phonological Awareness* (hereinafter, PA), that is to say, this is how the ability to detect and manipulate the units that make up oral language (words, syllables, intrasyllabic units and phonemes) has been named, is essential (Adams, 1992; Defior & Serrano, 2011; Treiman & Zukowski, 1991), because the automation of the segmentation and combination skills play an essential role in decoding and learning the relationships between graphemes and phonemes.

Another skill on which efficient reading is based is named *Rapid Automatised Naming* (hereinafter, RAN). RAN is the pace whereby familiar stimuli such as letters, numbers, colours or drawings (Denkla & Rudel, 1974) can be named. The relationship between reading and this skill has been demonstrated in several works conducted with children with and without reading learning difficulties (Caravolas et al., 2012; Georgiou, Parrila & Kirby, 2009; López-Escribano, De Juan, Gómez-Veiga & García-Madruga, 2013; López-Escribano, Sánchez-Hípola, Suro Sánchez & Leal Carretero, 2014; Wolf, Bowers & Biddle, 2000). This relationship varies depending on the stimulus used for the activity; naming letters or numbers

seems to be more closely linked to reading than to naming drawings or colours, while naming digits is more closely linked to reading pace than to accuracy (Savage & Frederickson, 2005; Schatschneider, Fletcher, Francis, Carlson & Foorman, 2004). Likewise, evidence was found in different works (Hulme & Snowling, 2014; Wolf et al., 2000; Wolf & Bowers, 1999) that link performance in RAN activities to reading of texts.

Denckla & Rudel (1976) also found that dyslexic patient referred to a lower number of words in activities of the named *Phonological Verbal Fluency* (hereinafter, PVF) than those children of their same age without any reading difficulties. Other researcher reported similar results (Frith, Landerl & Frith, 1995; Plaza, Cohen & Chevrie-Muller, 2002; Reiter, Tucha & Lange, 2005), who found found differences in the performance in PVF activities when comparing chronologically age-matched children with and without reading difficulties.

The results obtained in the research previously mentioned evidence that PA and RAN skills and performance in PVF activities are closely linked to decoding skills. Nevertheless, questions arise about the relationship of these skills and reading fluency, which has often been defined as a bridge between decoding and comprehension (Pikulski & Chard, 2005; Rasinski, 2010).

The scarcity of specific instruments can be noted when evaluating reading fluency in Spanish. In general terms, it is evaluated through reading activities of words and non-words, such as in the PROLEC-SE tests (Ramos & Cuetos, 1999), and in the LEE Test (Defior et al., 2006), which take into account the time and accuracy used when performing this activity. Nevertheless, taking the time used in reading draws a parallel between fluency and pace, which disregards a main aspect of reading fluency: comprehension. On the other hand, reading lexical items in isolation does not allow for information about aspects related to prosody to be obtained, an element that is also present in the definitions of reading fluency (Etxebarria, Gaminde, Romero & Iglesias, 2016; Rasinski, Rikli & Johnston, 2009; Schwanenflugel, Hamilton, Kuhn, Wisenbaker, & Stahl, 2004).

In order to obtain more representative measurements of reading fluency in Spanish, it is then necessary to evaluate it by reading texts. In this context, this work has two objectives. On one hand, analysing the impact of PVF, PA and RAN on the named *Reading of Words and Non-Words* (hereinafter, Reading of W&NW) and, on the other hand, studying the role of such variable (PVF, PA, RAN and Reading of W&NW) on reading fluency evaluated on the basis of an activity that has been named as Reading Out Loud a text (ROL) in group with students of Year 3, 5 and 7 of Primary Education without difficulties to learn to read. The results obtained will provide us with relevant information to design in the future a battery that enables to measure reading fluency.

Method

Participants

172 children were evaluated: 64 students from Year 3 (59.4% girls), with and average age of 8.58 years (*DE*= .38), 50 students from Year 5 (60% girls), with an average age of 10.7 years (*DE*= .41) and 58 students of Year 7 (44.8% girls), with an average age of 12.54 years (*DE*= .43). The participants were native Spanish speakers who did not have any sensory deficits or any neurological, language or learning disorders when at the time of the evaluation. The participants attended a private school in the Autonomous City of Buenos Aires. This evaluation was endorsed by the Directorate-General of Educational Planning of the Government of the City of Buenos Aires, the school board participated thereat and it also had the informed consent of the children's parents.

Proceeding

The participants answered voluntarily and were evaluated using five activities. The evaluation was conducted individually in five

sessions during class hours, in a room provided by the establishment, between September and October of the same academic year. The answers obtained in the activities evaluated were digitally recorded. The transcription was performed in the same way as the children's productions, using a level 1 orthographic criterion according to the *Network of European Reference Corporation* (Calzolari, Baker, & Kruyt, 1995).

Instruments

Activity 1

All the students were evaluated using an activity of Phonological Verbal Fluency (PVF), in which they had to say the greatest number of words starting with the phonemes /f/, /a/ and /s/ in one minute. Neither proper names nor families of words (dog, doggie, little dog, etc.) were accounted for in the score and the repeated words were eliminated. After reviewing the database, the resulting productions for each phoneme were accounted for.

Activity 2

The participants engaged in a rapid automatised naming (RAN) activity that was designed *ad hoc*, in which they had to name 50 letters and numbers that were repeated alternatively, side by side, distributed in an A4 sheet of paper displayed on a PC screen. The test was administered using the DMDX programme (Forster & Forster, 2003) and the total time used to finish the activity was taken into account.

Activity 3

In order to obtain data on the *Phonological Awareness* (PA) skills, all the students were evaluated using the Minimal Pair: Yes or No test (Fumagalli, Barreyro, Borzone & Jaichenco, 2014), which consists on matching 80 pairs of bisyllabic words. The test is composed of 60 pairs sharing a sublexical unit (syllable, rhyme, attack or phoneme) in the same position: at the beginning or at the end, and 20 not sharing it and working as distractors. The items used are substantives used with an average frequency M=216.35 (DS 423.62) (Martínez-Martín & García-Pérez, 2004). The activity was verbally managed without time-limitation. The right answers number was accounted for the analysis.

Activity 4

In order to obtain information about the process of decoding and lexical access, all the children engaged in the activity of reading words and non-words of the LEE Test (Defior et al., 2006). This type of activity is based on the dual route model for reading (Coltheart, 1978; Coltheart et al., 2001) and evaluates the decoding process by reading non-words and the lexical access processes by reading words. The activity presented consists on reading a list of 42 words and a list of 42 non-words. The number of words read correctly was taken into account to calculate the score.

Activity 5

In order to evaluate the reading of the *Texts Out Loud* (hereinafter, ROL), by which is meant the three short texts taken from schoolbooks in accordance with the level of each group of students were selected. The texts were selected this way in order to avoid artifices and to ensure that such material could be read by the participants *in the classroom*. The children from Year 3 read a text of 141 words taken from *Dame la palabra 3* (Leibovich, 2012); those from Year 5 read a text of 128 words taken from *Letras en red 5* (Salussoglia, 2008) and those from Year 7 read a text of 212 taken from *Ciencias Naturales I ES/ 7 EP* (Tomsin, 2013).

The students had to read the text out loud and, after that, they had to answer four questions in order to get a score for the text's comprehension. The score depended on whether the answers were complete or incomplete in the absence of a text (4 and 3 points, respectively), complete or incomplete in the presence of a text (2 and 1 points) and wrong or unanswered (0 points).

The test was administered using the DMDX programme (Forster & Forster, 2003), which

records the children's productions for subsequent transcription, as well as the time used.

In order to analyse the data, the average time used to read words in milliseconds, the proportion of words read correctly and the relevant score in terms of reading literacy were calculated.

Table 1. *Descriptive statistics*

	M	*DE*	*Mín.*	*Máx.*	*A*	*C*
Time used to read words from the text	745	353	379	2730	2,72	10,92
Proportion of words read correctly in the text	92,86	4,30	78,72	99,22	-1,24	1,24
Text comprehension	9,55	3,69	0	16	-0,10	-0,67
Reading of words and non-words	65,76	14,01	14	83	-1,59	3,09
RAN	52,92	14,07	31	98	1,02	1,17
Fluency of /f/	5,51	2,82	1	17	1,01	2,23
Fluency of /a/	7,17	3,18	1	16	0,11	-0,59
Fluency of /s/	7,03	3,10	1	14	0,30	-0,51
PA	18,26	1,52	13	20	-1,08	1,59

Source: Prepared by the authors

Data analysis

On the basis of the results obtained in the tests administered, two statistical analyses were performed. In first place, an analysis of the correlations between the tests was performed, followed by a path analysis. In this analysis, a model of relationship between the tests was proposed, whereby a latent fluency factor, comprised of the reading time (average number of words read in a text in milliseconds), the proportion of words read correctly and the comprehension score, which is influenced by the number of words and non-words read correctly and the RAN time. Likewise, reading of words and non-words correctly is influenced by the RAN time, the PA activity and a latent PVF factor based on the fluency of /f/, /a/ and /s/.

Results

In first place, in order to know the average and distribution of the values obtained by the participants in each one of the tests, the descriptive statistics were analysed. The descriptive statistics of the average, the standard deviation, the maximum and minimum value, the asymmetry and the kurtosis of the results obtained in the results are show in table 1.

An analysis of the correlation between the tests was then performed in order to know their level of association; the Pearson product-moment correlation coefficient *r* was used. The levels of association between the variables are shown in table 2.

The analysis of the correlations performed shows that, in general terms, the measurements envisaged in the ROL activity (time used to read words from the text, proportion of words read and text comprehension) show significant links[1] among Reading of W&NW, RAN, fluency of /f/ and PA. Nevertheless, the proportion of words read in the text was not related to fluency of /a/ or /s/, and the comprehension score was not associated to the fluency of /a/. Reading of

Table 2. *Correlations between the tests administered*

	TRWT	PWRT	TC	RW&NW	RAN	PVF /f/	PVF /a/	PVF /s/	PA
CTLPT	1								
PWRT	-,58**	1							
PA	-,37**	,43**	1						
RW&NW	-,61**	,47**	,33**	1					
RAN	,62**	-,33**	-,31**	-,51**	1				
PVF/f/	-,34**	,21**	,34**	,37**	-,32**	1			
PVF /a/	-,28**	,11	,10	,28**	-,21**	,55**	1		
PVF/s/	-,20**	,08	,19*	,27**	-,13	,54**	,39**	1	
PA	-,16*	,20*	,16*	,24**	-,04	,12	,17*	,10	1

** p < .01, * p < .05

Note: TRWT= Time Used to Read Words from the Text; PWRT=Proportion of Words Read from the Text; CT= Text Comprehension; RW&NW=Reading of Words & Non-Words; RAN=Rapid Automatised Naming; PVF/f/=Phonological Verbal Fluency/f/; PVF/a/=Phonological Verbal Fluency/a/; PVF/s/=Phonological Verbal Fluency/s/; PA=Phonological Awareness

Source: Prepared by the authors

W&NW revealed links to RAN, the three measurements of PVF and PA. When analysing the phonological verbal fluencies, the three measurements were significantly related among them, but only fluency of /a/ was associated to PA.

A path analysis was then performed, proposing a relational model between the variables analysed. The model proposed is mediation-type, whereby a latent fluency factor, comprised by the time used to read words from the text (TRWT), the proportion of words read from the text (PWRT) and text comprehension (TC) is influenced by the Reading of W&NW and RAN. Likewise, the Reading of W&NW is influenced by RAN, PA and a latent PVF factor based on the fluency of /f/, /a/ and /s/. Parallel to this, the measurements of RAN, PA and PVF are associated among them.

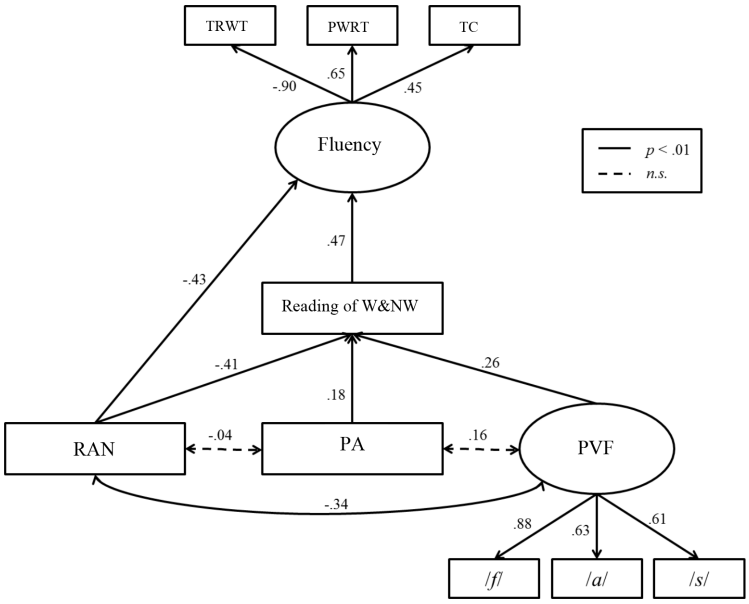

Figure 1. *Relational model between Reading Fluency, Reading of W&NW, RAN, PA and Verbal Phonology (VP)*

Source: Prepared by the authors

The path analysis showed that the model proposed was adjusted to the empirical data obtained from the participants [$\chi^2_{(22)}$ = 41.71, p < .01, χ^2/gl = 1.89, *GFI* = .95, *AGFI* = .90, *CFI* = .95, *TLI* = .93 and *RMSEA* = .07]. The values obtained for the model proposed are shown in figure 1[2]. When analysing the weighted regression, it is found a direct and significant impact of the Reading of W&NW on fluency [β = .47, p < .001] and an indirect and significant mediation effect of RAN on fluency. Therefore, RAN has a direct impact on fluency [β = -.43, p < .001] and an indirect impact through Reading of W&NW on fluency [β = -.20, p < .01]. Additionally, RAN has a direct and significant impact on the Reading of W&NW [β = -.41, p < .001]. On the other hand, PA and PVF have a pure mediation impact on fluency through Reading of W&NW. PA has a direct and significant impact on the Reading of W&NW [β = -.18, p < .01] and an indirect impact on fluency [β = .09, p < .001] and PVF has a direct and significant impact on the Reading of W&NW [β = .26, p < .001] and an indirect impact on fluency [β = .12, p < .001]. Likewise, when analysing the correlations within the model, it was found that RAN and PVF are associated between them [r = -.34, p < .001], unlike RAN and PA [r = -.04, p = .58], or PA and PVF [r = .18, p = .08].

Discussion

In order to obtain evidences to design a battery that evaluates reading fluency using texts in Spanish, this work aims at identifying whether PVF, RAN and PA have any impact on the Reading of W&NW (decoding and lexical access) on one hand and, on the other hand, it also aims at determining the impact of such variables (PVF, RAN, PA and the Reading of W&NW) on the reading fluency construct (reading pace, reading accuracy and comprehension), based on the data obtained in the evaluation of children of school-going age (Years 3, 5 and 7 of Primary Education) without any learning difficulties.

In the first analysis performed, as far as PVF is concerned, it was found that the fluencies /f/, /a/ and /s/ are related among them, but they do not have a homogeneous relationship pattern

when they are related to the other activities evaluated. Nevertheless, in the second analysis it was found that, on one hand PVF is related to RAN, which could demonstrate the efficiency whereby phonological representations are retrieved (Bowey, McGuigan & Ruschena, 2005; Bowey, Storey & Ferguson, 2004) and, on the other hand, it was also found that PVF has a direct and significant impact on the Reading of W&NW and an indirect impact on the fluency construct. These results are in line with those researches that assure that the skills to retrieve information following a phonological criterion implement certain aspects that are related to phoneme processing which, as stated in the introduction, are closely linked to the decoding skills (Frith et al., 1995; Plaza et al., 2002; Reiter et al., 2005).

As far as the activity that evaluates PA is concerned, the first analysis evidenced a relationship between this activity and the Reading of W&NW, and the second analysis evidenced that the PA activity has a direct and significant impact on the Reading of W&NW. These results are in line with many works on this issue, which identify the strong relationship between PA and the reading of words in terms of accuracy (Defior & Serrano, 2011; Moll et al., 2014). The PA skills in our sample would have no direct impact on reading fluency, but they would through Reading of W&NW.

As far as RAN is concerned, the first analysis showed it is related to the variables evaluated in the ROL activity (time used to read words from the text, proportion of words read from the text and text comprehension), and to the Reading of W&NW. The second analysis shows that RAN has a direct impact on fluency (a factor made up by the time used to read words from the text, the proportion of words read from the text and text comprehension) and an indirect impact on the Reading of W&NW[3]. It was found that RAN also has a direct and significant impact on the Reading of W&NW. In line the same line as Hulme & Snowling (2014), these data show that the pace and naming skills have a direct impact both on the decoding processes and lexical access, which are responsible for automatisation, as well as on the processes involved in reading fluency that result in text comprehension.

These results are in line with those researches that identify a greater impact of RAN than PA on the performance of expert readers (Vaessen et al., 2010). "Expert readers" are those readers who access automatically the lexical representations stored and do not exclusively rely on decoding processes when they read. In view of these results, it could be said that the phonological awareness skills (PA) are related to aspects inherent to decoding and that the rapid automatized naming skills (RAN) are related to the evocation of complete words required for automatized reading. Likewise, these data are consistent with prior research conducted in clear orthographic systems such as that of Spanish language, which found that RAN can be a more sensitive measurement of reading fluency than PA skills (Moll et al., 2014; Ziegler et al., 2010).

As far as the Reading of W&NW is concerned, in the first analysis a relationship is found between this variable and reading fluency, while in the second analysis it was found that the Reading of W&NW has a direct and significant impact on fluency. In other words, the decoding skills and lexical access have a direct impact on the time used to read a text, the proportion of words read correctly and the comprehension of what is read.

Finally, the results obtained in the second analysis show that the fluency construct is directly influenced by the measurements of RAN and of the Reading of W&NW. These results show that reading a text is a complex process that does not only involve decoding skills but also other aspects related to their automatisation, reflected on the direct relationship between RAN and fluency. As words become more familiar, their recognition becomes automatic and certain resources are released so that reading becomes fluid and thus

comprehensive (Ehri, 2005, 2014; LaBerge & Samuels, 1974).

In spite of the sample's size, the results allow for the variables that have a direct impact on the reading of words and non-words (PA, PVF and RAN) and the variables that have a direct (Reading of W&NW and RAN) and an indirect impact (PA and PVF) on the reading fluency construct to be identified. These data are relevant because there is evidence regarding this issue that shows that those children with difficulties to learn to read normally have a shortfall of PA (Defior & Serrano, 2011; Wolf & Bowers, 1999), FVF (Denckla & Rudel, 1976; Frith et al. 1995; Reiter et al., 2005), reading accuracy (reading of words and non-words) (Castles & Coltheart, 1993; Jiménez-Fernández, Defior et al., 2012) and RAN (Wolf, Bowers & Biddle, 2000; Wolf & Bowers, 1999), but no relationship between RAN and the reading fluency evaluated has been solidly identified, which could be a change option based on text reading. The data presented in this work analyse the relationship between reading performance of words in isolation and other skills necessary to read texts efficiently and fluently, understood as fast, accurate and comprehensive reading. On the basis of the results obtained, it is found that the RAN measurements have a stronger relationship with the reading fluency of texts, and that both the PA and the PVF measurements have an impact on the reading of W&NW that is not direct but through their relationship.

This information is important because it will allow for variables that establish a more direct relationship with reading fluency to be selected more accurately. On the basis of the results obtained, any battery allowing for the fluency construct to be evaluated should include activities that offer measurements of naming pace, lexical access and decoding, measurements accuracy and word reading pace within the framework of a text and comprehension measurements.

To sum up, it should be noted that this work has had several limitations because in the analysis of the data obtained, aspects related to prosody were not taken into account and their incorporation may provide us with significant data. The analysis of inter and intralexical pauses when reading out loud is proposed as a future line of research that could be added to the results obtained herein. In the other hand, adding data related to the evaluation of children with difficulties to learn to read chronologically or reading age-matched with those participants without any reading difficulties may be relevant to identify the differences between those variables that have a direct impact on reading fluency and those that have an indirect impact thereon. This information would allow for evidence to be added in order to evaluate and diagnose reading learning disabilities and to design materials to take clinical and pedagogical actions.

Notes

1 The fact that relationships are significant means that error probability is low, because the highest scores in any variable are linked to the highest scores in other variable, and so are the lowest scores.

2 The β negative values show that the lower the values in a variable are, the higher the values in the aforesaid variable are.

3 The indirect impact of RAN through reading of W&NW on fluency is explained on the basis of the impact of RAN on the reading of W&NW. This has an impact on fluency due to the direct impact of RAN on the reading of W&NW and the direct impact of the reading of W&NW on fluency.

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