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The Rapid Automatized Naming and Reading Fluency association: Testing the Visual Scanning Hypothesis

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Declaração de autoria de trabalho

Declaro ser a autora deste trabalho, que é original e inédito. Autores e trabalhos consultados estão devidamente citados no texto e constam da listagem de referências incluídas.

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Abstract

Rapid Automatized Naming (RAN) refers to how quickly an individual is able to name a number of highly familiar visual stimuli. Performance in RAN is usually positively correlated with reading ability in all known orthographies and ages. Several researchers have sought to analyze the contribution of the individual components of RAN for this association. However, there is still no consensus regarding the mechanisms underlying the shared variance amongst RAN and reading. In the present study, we investigated the visual scanning hypothesis, which suggests that the efficiency of the overlearned automatized procedures effecting left-to-right and top-to-down in skilled readers are at least partly responsible for the common variance of RAN and reading. Specifically, our main goal was to clarify if the directionality of oculomotor programming and attentional processing plays a role in the RAN-reading relationship in proficient readers. For this purpose, a total of 60 university students performed serial naming tasks (digits and letters) administered in two conditions: forward (left-to-right, top-to-bottom) and backward (right-to-left, bottom-to-top). As reading outcomes, we used two reading tasks with different presentation formats (columns and lines), both composed by high-frequency words, low-frequency words and pseudowords. We also applied a self-report measure to gather information about personal reading history. Overall, our results indicated moderate to strong correlations between all reading measures and all RAN tasks. However, a direct comparison between correlations demonstrated significant differences between the two conditions and stronger correlations when RAN was forward. A hierarchical regression analysis indicated a unique contribution of RAN forward to the shared variance of RAN and reading, above and beyond the contribution of RAN backward. In sum, our findings seem to support the visual scanning hypothesis, thus indicating that the directionality of oculomotor programming and attentional processing is important for the RAN-reading relationship in proficient readers.

Keywords: rapid naming, reading, visual scanning, oculomotor control.

Resumo

A nomeação rápida refere-se à velocidade com que um indivíduo consegue nomear um número de estímulos visuais altamente familiares. A sua avaliação é geralmente feita num formato serial, através de tarefas de Nomeação Rápida em Série (*Rapid Automatized Naming*). Estas tarefas são constituídas por cinco estímulos repetidos dez vezes cada um e distribuídos de forma aleatória numa matriz composta por dez colunas e cinco linhas. Os estímulos podem ser alfanuméricos (letras e números) ou não alfanuméricos (cores e objetos). A pontuação traduz-se no tempo que o participante demora a nomear todos os estímulos na ordem correta. Diversos estudos têm demonstrado que o desempenho nas provas de nomeação rápida se correlaciona positivamente com o desempenho na leitura, independentemente de vários fatores, como a idade ou o sistema ortográfico. Para um bom desempenho tanto na nomeação rápida como na leitura é necessária uma semelhante sincronização e integração de vários processos cognitivos, como a descodificação e integração da informação visual com a sua representação fonológica ou ortográfica, ou a coordenação dos movimentos oculares de forma sequencial, entre outros. Devido às semelhanças encontradas, a nomeação rápida tem-se tornado um contributo importante para a compreensão dos mecanismos envolvidos na leitura. Várias linhas de investigação se têm debruçado sobre o contributo de cada um dos seus componentes para o desempenho na leitura, dando origem a várias hipóteses teóricas sobre as causas que poderão estar subjacentes a esta associação. Alguns exemplos são o processamento fonológico, o processamento ortográfico ou a velocidade de processamento. Ainda assim, a influência da nomeação rápida no desempenho na leitura parece manter-se após o controlo das várias variáveis-chave, o que significa que o seu efeito singular está ainda por esclarecer e vai para além do contributo dos componentes até então identificados. Nesse sentido, a presente investigação tem como objetivo investigar o *visual scanning*, um potencial componente da relação entre nomeação rápida e leitura, que tem sido pouco estudado, no sentido de clarificar qual o seu contributo para esta associação. A hipótese do *visual scanning* sugere que a direcção do processamento oculomotor e atencional é em parte responsável pela variância partilhada entre nomeação rápida e leitura em leitores proficientes. Para avaliar o *visual scanning*, pode-se solicitar aos participantes para desempenhar uma tarefa de nomeação rápida no sentido normal (da esquerda para a direita e de cima para baixo) e no sentido inverso (da direita para a esquerda e de baixo para cima, começando no canto inferior direito da página e terminando no canto superior esquerdo). Supõe-se que a inversão da direcção da tarefa de nomeação rápida elimine o efeito benéfico dos processos oculomotores e atencionais, altamente treinados no sentido da leitura por leitores avançados, uma vez que os indivíduos são inexperientes na coordenação dos movimentos oculares de forma sequencial no sentido inverso ao da leitura. Sendo assim, seria expectável que se verificassem correlações mais fortes entre a versão normal da prova de Nomeação Rápida e o desempenho na leitura, assim como um contributo único e dessa versão normal da prova de Nomeação Rápida para a relação entre nomeação rápida e leitura. Participaram neste estudo 60 estudantes universitários com idades compreendidas entre os 18 e os 32 anos de idade. Foram aplicadas tarefas de nomeação rápida (dígitos e letras) em duas condições: normal e inversa. Como medidas de leitura foram usadas duas tarefas com diferentes formatos de apresentação (em que a leitura era feita por colunas ou por linhas), ambas compostas por palavras de alta frequência, palavras de baixa frequência e pseudopalavras. Foi também aplicado um questionário sobre a história pessoal de leitura. Os resultados confirmaram a vantagem da condição normal sobre a inversa, demonstrando diferenças significativas entre as correlações que ambas estabeleceram com as medidas de leitura, embora se tenham verificado correlações moderadas a fortes entre todas as medidas de nomeação rápida e todas as medidas de fluência de leitura. Posteriormente foi realizada uma análise de regressão hierárquica, que indicou que a condição normal parece explicar parte da variância partilhada entre nomeação rápida leitura, e que o seu contributo ultrapassa aquilo que é explicado pela condição inversa. Não se verificaram diferenças significativas entre as várias dimensões de leitura avaliadas (mais dependentes de processos fonológicos ou mais dependentes de processos ortográficos), em termos das correlações estabelecidas com as medidas de nomeação rápida. Não se verificou também um efeito diferencial do formato de apresentação das tarefas de leitura, em termos das correlações estabelecidas com as tarefas de nomeação rápida. Em suma, os resultados do presente estudo dão suporte à hipótese do *visual scanning*, sugerindo que a direção do processamento oculomotor e atencional parece constituir um componente importante para sustentar a relação entre nomeação rápida e leitura, pelo menos em leitores proficientes.

Palavras-chave: nomeação rápida, leitura, programação oculomotora.

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1. Introduction

1.1. Rapid Automatized Naming

Naming speed refers to how quickly an individual is able to name a number of highly familiar visual stimuli. It is usually assessed in a serial format, through the Rapid Automatized Naming (RAN) task (e.g. Kirby et al., 2010; Logan, Schatschneider & Wagner, 2011).

In the standard version of the RAN task, developed by Dencka and Rudel (1974, 1976), five different familiar stimuli are visually presented in a grid of ten columns and five rows, each repeated ten times in a random order. The participant is required to name all of the 50 items as quickly and accurately as possible. The stimuli can be either alphanumeric, such as letters or digits, or non-alphanumeric, such as objects or colors. The score of the task is measured by the time it takes to name all of the items in their correct order (in left-to-right serial fashion). Self-corrections and errors are usually not taken into account, but when they occur there is an increase in the time it takes to complete the task. In addition, a qualitative interpretation is possible (Norton & Wolf, 2011).

Successful performance in RAN requires a quick and accurate activation and synchronization of many processes. Wolf and Bowers (1999) enumerated seven processes involved in serial letter naming tasks that can also be depicted for other types of stimulus:

> (a) attention to the letter stimulus; (b) bihemispheric, visual processes that are responsible for initial feature detection, visual discrimination, and letter and letter-pattern identification; (c) integration of visual features and pattern information with stored orthographic representations; (d) integration of visual information with stored phonological representations; (e) access and retrieval of phonological labels; (f) activation and integration of semantic and conceptual information; and (g) motoric activation leading to articulation (p. 418).

1.2. RAN and reading

In their original study, Denckla and Rudel (1976) showed that tests of rapid automatized naming of colors, objects, numbers and letters could differentiate the children with dyslexia from both normal readers and nondyslexic learning disabled children. The establishment of RAN as a predictor of success in reading initiated an entire area of inquiry within Psychology (Denckla & Cutting, 1999). The speed at which a RAN task is performed is usually positively correlated with the participant's reading ability (Araújo, Reis, Petersson

& Faísca, 2015; Kirby et al., 2010; Kirby, Parrila & Pfeiffer, 2003; Kuperman, Van Dyke & Henry, 2016; Logan et al., 2011; Norton & Wolf, 2011; Wolf & Bowers, 1999). This correlation seems to be stronger when RAN uses alphanumeric rather than non-alphanumeric symbols (Araújo et al., 2011; van den bos, Zijlstra & Spelberg, 2002; Wolf and Bowers, 1999) and in impaired readers (e.g. Araújo et al., 2015). Furthermore, RAN has been pointed as one of the best and more consistent predictors of reading performance (Araújo et al., 2015; Kirby et al., 2010; Kuperman et al., 2016; Norton & Wolf, 2011) across all known orthographies (Araújo et al., 2015; Kirby et al., 2010) and ages (Kirby et al., 2010; Kuperman et al., 2016; Vaessen et al., 2010; Van den Bos et al., 2002).

As a result, RAN tasks are valuable tools to assess preschool children in order to early indicate if there is a risk for reading difficulties. These tasks provide a measure of development and efficiency of processes related to reading ability (Norton & Wolf, 2011), considering that performance in both RAN and reading seems to tap into shared cognitive processes (e.g. Araújo et al., 2015; de Jong, 2011; Kirby et al., 2010). Thus, RAN tasks can be helpful to better understand the cognitive processes supporting reading fluency in dyslexic and non-dyslexic individuals, as well as what differentiates both and why dyslexic individuals are poor readers. In general, it may give an important contribution to the understanding of reading performance (Kirby et al., 2003; Kirby et al., 2010 Norton & Wolf, 2011) which has an impact not only on how developmental reading disabilities in children are predicted but also how they are diagnosed and treated (Norton & Wolf, 2011; Wolf & Bowers, 1999).

Although several studies have been conducted with children, clinical populations or lower literacy adults, few studies on normal populations investigated the RAN-reading relationship through adulthood. Van den bos et al. (2002) addressed this issue with eight experimental samples of participants with ages between 8 and 65 years old and found that correlations did not decrease but, instead, increased with age. No asymptotic pattern was observed in the total age range studied, as the reading speed of mature adults remained significantly faster than the reading speed of the adolescents. In a review, Araújo et al. (2015) also concluded that RAN may tap a key dimension of reading ability with persistent effect through the course of development, although some studies demonstrate that correlation coefficients can decline with increasing reading experience. It is being discussed that further investigation would be crucial for a better comprehension of the developmental interrelations among RAN and reading ability.

As Norton and Wolf (2011) explain, RAN and reading require the synchronization and integration of many shared processes. It ranges "from eye saccades to working memory, to the connecting of orthographic and phonological representations", also "depending on the ability to automate both the individual linguistic and perceptual components and the connections among them in visually presented tasks" (p. 430).

Although considering RAN a complex multicomponential circuitry, many researchers have sought to study the contribution of its individual components to the overall reading performance. Hence, there are a number of theoretical proposals for the causal underpinnings of this association, including phonological, orthographic and other cognitive factors.

Nevertheless, the influence of RAN seems to remain even after controlling for all the key variables, which means it may have a unique and yet undetermined effect on reading that goes beyond other effective predictors (Araújo et al., 2015; Kirby et al., 2010; Logan et al., 2011). Thereby, although we can find an extensive body of research on this subject, there is still no consensus regarding the mechanisms underlying the single contribution of RAN to reading ability (for a review, see Araújo et al., 2015). As Kirby et al. (2010) suggest, maybe "each theory has a piece of the puzzle but none provides a complete account of this relationship" (p. 343).

1.2.1 Phonological processing

RAN tasks require the ability to rapidly and efficiently access and retrieve stored phonological information from long-term memory. Thus, as these tasks involve transferring visual stimuli to phonological codes, many believe it reflects partially the functioning of phonological processing (e.g. Torgesen, Wagner, Rashotte, Burgess & Hecht, 1997). However, even though RAN depends on phonological procedures, it may be inaccurate to consider it as a phonological subset. In a review, Norton & Wolf (2011) summarize some arguments against the phonological theory, such as the non-significant correlation of RAN with phonological awareness or phonological memory, as well as the unique variance that RAN account for reading ability, not shared with phonological skills. It is also possible to find evidence coming from genetic and neuroimaging studies, which locate different brain substrates for RAN and phonological awareness. Moreover, although phonological deficits can cause reading disabilities, many children have reading difficulties despite intact phonological awareness and decoding skills. This led Wolf and Bowers (1999) to consider deficits in the underlying processes of naming speed as a second core deficit in dyslexia, independent from the phonological deficit.

Accordingly, other researchers found RAN to make an independent contribution to reading ability after the phonological awareness was controlled for (Bowers & Swanson, 1991; de Jong, 2011; Kirby et al., 2003; Logan et al., 2011; Wolf et al., 2002).

Summing up, these findings suggest that there may be other cognitive factors underlying the relationship between RAN and reading that goes beyond phonological processing.

1.2.2. Orthographic processing

Orthographic processing involves the ability to recognize and process letters and letter patterns in words. As children's reading skills develop, the role of orthographic knowledge in reading process increases as they start to rely more on whole-word recognition rather than phonological decoding. Consequently, some researchers found that the concurrent correlations between RAN and orthographic processing tend to increase across time whereas the correlations between RAN and phonological awareness tend to decrease. These results led Bowers and Wolf (1993) to propose an orthographic basis for the RAN-reading relationship, suggesting it may be mediated by factors related to, or subserving, orthographic processing.

In line with this view, other studies found RAN to be more related to reading tasks that rely primarily on orthographic knowledge (such as the reading of high-frequency words) compared to tasks requiring mainly phonological decoding skills (such as the reading of non-words) (e.g. Araujo et al., 2011; Georgiou, Parrila, Kirby and Stephenson, 2008).

However, in a recent meta-analysis, Araújo et al. (2015) showed that RAN correlates with reading performance regardless of whether the literacy measure relies more on phonological or orthographic coding skills. The authors suggest that variations in RAN performance might reflect a common underlying mechanism for the different reading measures.

In a different review, Kirby et al. (2010) found that naming speed seems to be, at least, partly distinct from the effects of phonological awareness, orthographic processing, and processing speed. In fact, evidence shows that it remains a significant predictor of reading ability when other predictors, including orthographic processing, are controlled for.

1.2.3. General processing speed

Some studies like Kail and Hall (1994), and later Kail, Hall and Caskey (1999), suggest that the increase in RAN performance can be considered a consequence of global processing speed (as cited in Georgiou et al., 2008). Namely, the speed of processing increases during development on a range of perceptual and cognitive tasks, which made some researchers argue that RAN performance becomes more rapid across time because of age-related changes in global retrieval speed. This increase in speed could be the common factor underlying the correlation between RAN and reading fluency.

Nonetheless, although it assuredly plays a role in the RAN-reading relationship, the speed of processing does not explain the magnitude of this association, considering that RAN seems to make a significant contribution to reading even after processing speed is controlled (for a review, see Norton & Wolf, 2011).

Furthermore, to support the theory which postulates that the shared variance between RAN and reading lies in a global processing mechanism, the speed at which discrete and serial naming tasks are complete should grow at a similar rate. However, when comparing both versions, Logan et al. (2011) found differential changes in the speed at which the tasks were performed. These findings indicate that the two tasks are measuring other components besides speed of processing, which means it does not account for all of the variance in RAN as it relates to reading.

1.2.4. Serial vs. discrete naming

There are two versions of the naming speed task. As described before, naming speed is traditionally assessed in a serial fashion, but there is another way to measure it. In discrete (or isolated) naming, the stimuli are presented individually (one by one) in a screen and the participant is required to name each item as quickly and accurately as possible. The time between the presentation of the stimuli to voice onset is measured and the final score is the mean naming latency over all individual items (e.g. de Jong, 2011; Kirby et al., 2010).

Although the two versions of the task are apparently related, they were found to be only moderately correlated (Logan et al., 2011). Furthermore, the added demands of serial naming seem to make it a better predictor of reading ability (Bowers & Swanson, 1991; Logan et al., 2011; Wolf & Bowers, 1999) as it is claimed that discrete naming has nothing to offer to the prediction of reading that is not accounted for by serial naming. Norton & Wolf (2011) add that both may not be even governed by the same underlying system, as suggested in some explanations of RAN. In fact, discrete naming mainly measures phonological access of individual items, because it eliminates oculomotor and sequencing requirements. As explained by Jones, Branigan and Kelly (2009), serial naming is a more complex task that requires some additional processes, such as "saccadic eye movements and sequencing of multiple items, which in itself requires inhibition of previous (already named) stimuli and efficient processing of upcoming items".

On the other hand, de Jong (2011) found the relationship between discrete or serial naming and reading to be dependent on and coincident with the presentation format (also discrete or serial) of the word reading task. However, serial naming was found to be overall more strongly correlated to word reading than discrete naming, regardless of the presentation format.

In a different study, to examine if there remained any variance in reading that could be uniquely explained by serial naming, Logan et al. (2011) found that not only serial naming uniquely predicted reading but this association was stronger when discrete naming was controlled for. It was concluded that isolated naming worked as a suppressor variable in the relation of serial naming with reading.

Accordingly, in a review, Kirby et al. (2010) showed that correlations with reading were usually weaker in discrete naming. They suggested that it can give us a clue about what is underlying the association between serial naming and reading, as it may rely on the different demands of the two versions of the task.

1.2.5. Visual scanning

As previously mentioned, it was suggested that there may be important differences between discrete and serial naming tasks that are indicative of serial naming's unique relation with reading (Kirby et al., 2010; Logan et al., 2011). There must be at least one component of serial naming that remains once isolated naming is controlled for; even though it remains unclear, Logan et al. (2011) listed some possibilities. Namely, the integration of several components required in serial naming and reading but not in isolated naming, like the eye-movements that follow the same motions in serial naming as they do in reading, repeating the process in which the eyes move from left to right and jump from one line to the following, quickly engaging and disengaging from one item to the next.

Another hypothesis raised by Logan et al. (2011) was the ability to process parafoveal information, which is important for reading performance and may be an advantage in serial naming tasks. The way readers manage to process and integrate parafoveal and foveal information can be determinant to reading fluency. In serial naming and when reading aloud, the eyes fixate on the foveal item in order to identify it and before articulation starts, viewers automatically begin to preprocess the parafoveal item (the next item to be named), facilitating its recognition. As typical users use right-side parafoveal information to facilitate the reading process, it was hypothesized that it can also be an advantage in serial naming (Jones, Ashby & Branigan, 2013; Jones et al., 2009), therefore accounting for the differences between serial and discrete naming performance.

The visual scanning hypothesis, as proposed by Protopapas, Altani and Georgiou (2013), refers to the idea at which "the efficiency of the overlearned automatized procedures effecting left-to-right-then-down in skilled readers makes up for at least some portion of the yet unaccounted-for common variance between RAN and reading" (p. 454). As it relies on the fixed directional processing of the RAN arrays, to test this hypothesis, Protopapas and colleagues asked participants to perform a conventional RAN task and then a backward RAN condition, starting at the bottom right toward the top left. They argued that a backward condition would negate the oculomotor procedures used for reading and the asymmetric perceptual span advantage that proficient readers may have, since they would be equally inexperienced with coordinating serial eye movements in the direction opposite to that of reading. Therefore, for the visual scanning hypothesis to be correct, backward RAN should be less correlated with reading than standard RAN. However, Protopapas et al. found equally strong correlations between reading fluency and RAN in both conditions. These results led them to conclude that the directionality of the attentional processing is irrelevant for the RAN-reading relationship.

A previous study from Scarborough and Domgaard (1998, as cited in Protopapas et al., 2013) also tested this hypothesis using a similar procedure, and found non-significant differences between the correlations of reading accuracy with digit naming in the forward and in the backward conditions. Likewise, this finding led them to reject the visual scanning hypothesis.

Nonetheless, both studies were based on a sample of children under the age of 12 (M = 11 years and 10 months, SD = 4 months). Albeit these children were considered proficient readers with some years of reading practice, could not be Protopapas et al. (2013)'s conclusions contingent to the degree of reading skills of their specific sample? Can we reliably generalize their results to an adult population with a vast, over-trained reading experience?

2. The current study

Focusing on the concurrent relationship between RAN and reading fluency across ages and orthographies, our main goal is to uncover a specific component underlying this association. In the present study, we aim to investigate the visual scanning hypothesis further, in order to clarify if the oculomotor programming and the directionality of attentional processing play a role in the RAN-reading relationship, as initially proposed by Protopapas et al. (2013). We will focus our study on a population of advanced readers, with a vast reading experience, rather than commonly studied populations of children, clinical populations or lower literacy adults. Using such an adult population offers the opportunity to evaluate the visual scanning hypothesis in a sample of proficient readers, with over-trained oculomotor programming for effective left-to-right-then-down reading.

For this purpose, serial naming tasks (digits and letters) will be administered in two conditions: forward and backward. As reading outcomes, we will use two reading tests (based on word and non-word reading) and a self-report measure to gather information about personal reading history.

The main goal of our study is to evaluate the effect of directionality of oculomotor programming and attentional processing in the RAN-reading relationship in proficient adult readers.

Considering previous evidence, we expect to find an association between RAN and reading, although we anticipate that correlations can be weaker than those found in populations of children or poor readers. We assume that in a population of advanced adult readers, with years of reading experience, we will have a higher probability of finding the asymmetric perceptual span or the highly skilled direction-specific visual processing that Protopapas et al. (2013) was trying to uncover in a population of children. Thus, we expect to find stronger correlations between RAN forward and reading fluency and we hypothesize that RAN forward will account for additional unique variance beyond the contribution of RAN backward to reading performance.

Finally, although it is not the focus of our study, considering that correlations between RAN and orthographic processing tend to increase across time, we expect to find stronger correlations between RAN and reading measures that rely primarily on orthographic knowledge (word reading tasks) than between RAN and reading measures that rely primarily on phonological decoding (pseudoword reading tasks), as well a possibly stronger effect of RAN directionally on word reading, when compared to non-word reading.

3. Materials and methods

3.1. Participants

A total of 60 university students (20 female and 40 masculine) with age ranged from 18 to 32 years old (M = 22.37, SD = 2.89) and education level between 12 and 18 years (M = 15.48, SD = 1.61) were recruited on a voluntary basis from the community.

All participants were native Portuguese speakers and naïve regarding the purpose of the research. Both verbal and written informed consent were obtained prior to participation. Additionally, all participants reported negative on cognitive or learning impairments, history of alcohol or other substance abuse in the last six months, history of neurological or psychiatric disorder, acquired head trauma, current psychotropic drug treatment or other health treatment for anxiety, clinical depression or any other psychiatric condition, as well as neurological or medical condition that could potentially affect cognitive functioning. They also reported normal or corrected-to-normal vision.

3.2. Reading measures

As reading measures, we used a reading questionnaire and two reading fluency tasks.

The Adult Reading History Questionnaire (ARHQ) was developed by Lefly and Pennington (2000) to gather reading history information and measure the risk of reading difficulties in adults. The Portuguese version (Alves & Castro, 2005) is a 25-item self-report tool responded to with a five-points rating scale (ranging from 0 to 4), resulting in a score ranging from 0 to 100. The result is divided by the maximum possible score (100) to generate a percentage final score. Higher scores represent greater reading difficulties. In addition, there are four final informative items about educational level and reading/writing difficulties.

To assess reading fluency, two word reading tasks were administered. The tasks were displayed on a computer screen, using *Presentation* software (www.neurobs.com). Both included three subtasks composed by high-frequency words, low-frequency words and pseudowords. For each subtask, participants were instructed to accurately read aloud as many words as possible in 30 seconds. The score is reading speed, computed as the number of correctly read stimuli per second. The major difference between the two reading fluency measures was the presentation format.

For the reading task presented in a column format (Reading-Columns), participants were instructed to read the words in a vertical top-down way, column by column. Each list was composed of 90 stimuli distributed on six sheets (15 stimuli per sheet) of increasing difficulty with respect to the number of syllables (2–4), syllabic structure (with and without consonant clusters), and phoneme-grapheme correspondence rules (regular and irregular). This task integrates the ADLER battery (Faísca et al., 2018).

For the reading task presented in a row format (Reading-Lines), participants were instructed to read the words in a horizontal way, from left to right, row by row. Each list was composed of 230 stimuli distributed on six sheets (with a maximum of 42 stimuli per sheet). This reading task was specifically developed for the present study, in order to understand if the correlation between RAN and reading would be affected by the format at which reading fluency is assessed. This version was created to overcome one of Protopapas et al. (2013) possible limitations. As mentioned in their study, it can be argued that testing word fluency in a column format rather than in a row format could have weakened the conclusions of their research, considering that visual scanning was not fully shared among RAN and reading measures.

The words of both tasks were different but equivalent in terms of frequency, mean length mean and syllabic structure (see Annex 3 and 4).

3.3. RAN measures

Four naming speed tasks were administered, including RAN-Letters and RAN-Digits, both in Forward (RAN-LF; RAN-DF) and Backward (RAN-LB; RAN-DB) conditions. These tasks were based on the RAN tasks included in the BFUP battery (*Bateria Fonológica da Universidade do Porto*; Alves et al., 2007).

The RAN tasks were based on the classical paradigm of Denckla and Rudel (1975). Letters included a, d, o, p and s, such as in the original version, because they are high-frequent in the Portuguese language. The selected digits were monosyllabic and included 1, 2, 3, 6 and 7.

Each task was composed of five different stimuli visually presented in a grid of ten columns and five rows, each repeated ten times at random. Participants were instructed to name all of the 50 items as quickly and accurately as possible. The score of the task was measured by the time each individual took to name all of the stimuli in the correct order, following the instruction.

In the forward and regular condition, participants were instructed to name all of the items in a left-to-right serial fashion. In the backward condition, participants were instructed to name the items starting at the lower right corner and working leftward, line by line, to finish at the top-left corner.

Participants' output was recorded on the computer via a headset. The total naming duration, from the onset of naming the first item to the offset of the last one, was subsequently measured on the waveform using *Audacity* software.

3.4. Procedure

After obtaining the informed consent, participants started by completing a demographic questionnaire providing information about age, gender, education level, and current occupation. All participants were assessed individually, in one session. The tasks were applied in a controlled environment, for no longer than 30 minutes. Administration order was fixed: after completing the demographic questionnaire, ARHQ was applied, followed by one reading task (Reading-Lines), Rapid Automatized Naming for Digits (forward version; RAN-DF), Rapid Automatized Naming for Letters (backward version; RAN-LB), a second reading task (Reading-Columns), Rapid Automatized Naming for Digits (backward version; RAN-DB) and finally, Rapid Automatized Naming for Letters (forward version; RAN-LF).

4. Results

Statistics were generated on computer software SPSS (Statistical Package for Social Sciences).

Descriptive statistics and normality tests for reading measures and rapid naming times are shown in Table 4.1.

Overall, the QHL scores obtained by the participants are slightly below the expected, considering their school level (Alves and Castro, 2005).

Participants reading performance was faster in the column format task compared to the line format task (HFW: $t = 6.13, p < .001$, Cohen's $d = 0.55$; LF: $t = 5.17$, $p < .001, d = 0.43$; PW: $t = 21.24, p < .001, d = 1.86$). Error rates found in reading measures ranged from 0.8% to 8.3% in line format (HFW-Lines and PW-Lines, respectively) and from 0.5% to 4.6% in column format (HFW-Columns and PW-Columns, respectively). Z-scores were computed only for column format (based in a large sample of 156 university students; Faísca et al., 2018) and indicated reading accuracy and speed within the expected range (mean z-scores between -0.09 and 0.20, with the exception of pseudoword reading accuracy which z-score average was 0.98, indicating a superior performance in the present sample).

Z-scores for RAN forward versions were computed, based on a population with the same characteristics as ours (Alves et al., 2007), indicating a regular performance on RAN-Digits (mean z-score = 0.20) but a somewhat lower than expected performance on RAN-Letters (mean z-score = -0.89). Few errors were found in RAN tasks and were not taken into account in the analysis. One error (committed by one participant) occurred in RAN-DF; a maximum of two errors occurred in RAN-DB (committed by one participant). Overall, across the 60 participants and the four RAN tasks, only 24 errors were observed, corresponding to an average 0.2% error rate.

There were differences between RAN performance in forward and backward versions, with the backward versions showing significant medium longer times, therefore indicating worse performances (for RAN Digits: $t = 8.61, p < .001, r = .85$, Cohen's $d = 0.61$; for RAN Letters: $t = 9.90, p < .001, r = .77, d = 0.90$). Although there was no difference between RAN-Digits and RAN-Letters in the forward version ($t = 0.78, p = .436$, Cohen's $d = 0.07$), RAN-LB was significantly slower than naming digits ($t = 3.53, p = .001, d = 0.27$).

Table 4.1. Descriptive statistics and normality tests for the reading measures and rapid naming times ($n = 60$).

		Mean ± SD	*Min – Max*	*Skewness*	*Kurtosis*	*S-W*	*S-W p-value*
QHL							
	%	0.32 ± 0.10	0.08 – 0.59	0.18 ns	0.13 ns	0.99	.910
	Z-scores	-0.31 ± 0.91	-2.41 – 2.14				
HFW-Columns							
	Words/sec	2.28 ± 0.30	1.73 – 3.03	0.59 ns	-.011 ns	0.96	.065
	Z-scores	0.27 ± 0.48	-0.61 – 1.47				
LFW-Columns							
	Words/sec	1.71 ± 0.24	1.17 – 2.40	-0.06 ns	0.17 ns	0.98	.365
	Z-scores	0.30 ± 0.49	-0.82 – 1.70				
PW-Columns							
	Words/sec	1.38 ± 0.23	0.83 – 1.83	-0.17 ns	-0.26 ns	0.98	.603
	Z-scores	0.20 ± 0.54	-1.11 – 1.27				
HFW-Lines							
	Words/sec	2.12 ± 0.31	1.57 – 2.90	0.55 ns	-0.07 ns	0.97	.097
LFW-Lines							
	Words/sec	1.60 ± 0.29	1.07 – 2.27	-0.01 ns	-0.98 ns	0.97	.090
PW-Lines							
	Words/sec	0.98 ± 0.21	0.63 – 1.47	0.34 ns	-0.81 ns	0.96*	.044
RAN-DF							
	Time (secs)	15.07 ± 2.88	9.16 –	0.16 ns	-0.64 ns	0.98	.442
	Z-scores	0.20 ± 1.13	-2.44 – 2.97				
RAN-DB							
	Time (secs)	16.81 ± 2.80	10.29 –	0.40 ns	0.04 ns	0.97	.218
RAN-LF							
	Time (secs)	15.25 ± 2.30	10.27 –	0.31 ns	-0.03 ns	0.99	.769
	Z-scores	-0.89 ± 1.14	-3.36 – 1.90				
RAN-LB							
	Time (secs)	17.58 ± 2.83	11.62 –	0.59 ns	0.33 ns	0.97	.096

Note. SD = standard-deviation; S-W = Shapiro-Wilk test for normality; QHL = Portuguese version of ARHQ; HFW = high frequency words; LFW = low frequency words; PW = pseudowords; DF = digits forward; DB = digits backward; LF = letters forward; LB = letters backward.
ns – $p > .05$ for testing the hypothesis of null skewness and kurtosis coefficients.
* $p < .05$

Pearson correlation coefficients between reading measures and rapid naming times were determined and displayed in Table 4.2.

As expected, correlations between RAN and reading fluency measures were negative, indicating an association between shorter RAN times and a higher reading fluency.

Table 4.2. Correlations between reading measures and rapid naming times ($n = 60$).

	Reading-Columns						*Reading-Lines*						*QHL*	
	HFW		*LFW*		*PW*		*HFW*		*LFW*		*PW*			
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
RAN-DF	-.68**	< .001	-.55**	< .001	-.71**	< .001	-.67**	< .001	-.63**	< .001	-.50**	< .001	.11	.402
RAN-DB	-.62**	< .001	-.47**	< .001	-.61**	< .001	-.57**	< .001	-.46**	< .001	-.33*	.010	.06	.634
RAN-LF	-.65**	< .001	-.55**	< .001	-.68**	< .001	-.61**	< .001	-.56**	< .001	-.48**	< .001	.12	.363
RAN-LB	-.46**	< .001	-.32*	.014	-.47**	< .001	-.48**	< .001	-.35**	.006	-.32*	.013	.02	.890

Note. QHL = Portuguese version of ARHQ; HFW = high frequency words; LFW = low frequency words; PW = pseudowords; DF = digits forward; DB = digits backward; LF = letters forward; LB = letters backward.
*$p < .05$
** $p < .01$

Correlations ranged from moderate to strong (between -.32, referring to RAN-LB and LFW-Columns, and -.71, referring to RAN-DF and PW-Columns) and were always significant ($p < .014$). Conversely, there were no significant correlations between RAN (any version) and the self-report reading measure (QHL; all $r < .12, p > .3$).

To specifically test the existence of reliable differences between correlations of RAN forward and RAN backward versions with reading, we followed the Steiger's (1980) statistical procedure (Table 4.3 presents the resulting p-values).

Concerning reading by columns, although correlations with RAN-DF were always higher than correlations with RAN-DB, differences were not significant ($p > .2$), with a possible exception for pseudowords ($p = .055$). However, correlations with RAN-LF were significantly higher than correlations with RAN-LB for the three types of reading items ($p < .012$).

Concerning reading by lines, correlations with RAN forward were always significantly (or nearly significantly, $p < .08$) higher than correlations with RAN backward, for both types of RAN tasks (digits or letters) and for all the three types of reading items (high and low frequency words, as well as pseudowords).

Overall, correlations with RAN-forward times were systematically higher than correlations with RAN-backward times; this advantage was observed across RAN tasks (letters or digits) and reading items (words and pseudowords). However, those differences did not always reach statistical significance (namely, in the case of RAN-digits and reading by columns).

Table 4.3. The differential effect of the RAN version (forward versus backward) on the correlations between reading measures and rapid naming times: p-values according to Steiger's procedure (n= 60).

	Reading-Columns			*Reading-Lines*			*QHL*
	HFW	*LFW*	*PW*	*HFW*	*LFW*	*PW*	
RAN Digits (DF versus DB)	.296	.207	.055	.061	.004	.011	.517
RAN Letters (LF versus LB)	.012	.004	.004	.078	.007	.045	.259

Note. QHL = Portuguese version of ARHQ; HFW = high frequency words; LFW = low frequency words; PW = pseudowords; DF = digits forward; DB = digits backward; LF = letters forward; LB = letters backward.

No significant differences were observed between the correlation of QHL with forward and backward versions of RAN ($p > .2$).

Using Steiger's (1980) statistical procedure for testing those differences between correlation coefficients, only four out of twenty tests were significant. The correlation between RAN-DB and high-frequency words reading seemed to be stronger than was the correlation with pseudowords reading, but only for the lines format (p = .030). The correlations between all RAN versions and pseudowords reading were stronger for the column reading format than for the row reading format ($p \leq .06$). To investigate the unique contribution of RAN forward and backward versions to reading fluency, hierarchical regression analyses were conducted, changing entrance order of the predictors (Table 4.4.).

The results indicated that when RAN forward entered in the first place (Model 1), it accounted for about 23% to 51% of variance in reading (considering both Digits and Letters), whereas RAN backward, when entered in the second place, had no significant contribution to reading variability ($\Delta R^2 \leq .03, p > .1$).

When RAN forward entered in the second place (after RAN-backward, in Model 2), a substantial amount of variance in reading was explained ($\Delta R^2 \geq .08$, $p < .014$). Although RAN-backward contributed significantly to reading (11%–37%), it is clear that RAN-forward accounted for a unique fraction of reading variance.

Table 4.4. Hierarchical regressions predicting reading measures from rapid naming tasks (n= 60).

		Reading-Columns						*Reading-Lines*					
		HFW		*LFW*		*PW*		*HFW*		*LFW*		*PW*	
Step	*Variable*	ΔR^2	*p*	ΔR^2	*p*	ΔR^2	*p*	ΔR^2	*p*	ΔR^2	*p*	ΔR^2	*p*
RAN-Digits													
Model 1													
1	RAN-DF	.46	.000	.30	.000	.51	.000	.45	.000	.40	.000	.25	.000
2	RAN-DB	.01	.365	.00	.946	.00	.891	.00	.952	.02	.155	.03	.127
Model 2													
1	RAN-DB	.39	.000	.22	.000	.37	.000	.32	.000	.21	.000	.11	.010
2	RAN-DF	.08	.005	.08	.014	.13	.000	.13	.001	.21	.000	.17	.001
RAN-Letters													
Model 1													
1	RAN-LF	.42	.000	.30	.000	.46	.000	.37	.000	.31	.000	.23	.000
2	RAN-LB	.00	.632	.02	.154	.01	.455	.00	.852	.02	.248	.01	.491
Model 2													
1	RAN-LB	.28	.000	.10	.014	.22	.000	.23	.000	.12	.006	.10	.013
2	RAN-LF	.21	.000	.22	.000	.24	.000	.14	.001	.21	.000	.14	.002

Note. HFW = high frequency words; LFW = low frequency words; PW = pseudowords; DF = digits forward; DB = digits backward; LF = letters forward; LB = letters backward.

This pattern of results is mostly similar for all the reading measures and for both RAN tasks (digits and letters).

Overall, the results indicated a unique and significant contribution of RAN forward to all types of reading items that is not shared with RAN backward versions.

On the contrary, although RAN backward accounted for a significant fraction of reading variance, its contribution overlaps RAN forward's. Therefore, no specific contribution can be attributed to RAN backward besides what was already explained by RAN forward.

5. Discussion

The main goal of our study was to test whether the overlearned left-to-right and downward visual scanning direction required by reading in occidental writing systems may partly underlie the association between RAN and reading. This "visual scanning hypothesis" was proposed by Protopapas et al. (2013) in an attempt to explain the RAN-reading association as well as the advantage of serial over discrete naming. To test this visual scanning hypothesis, we followed Protopapas et al.'s experimental paradigm (2013) and manipulated the direction of RAN, creating a backward version (right-to-left, bottom-to-top) to contrast with a forward version (left-to-right, top-to-bottom – the direction of reading in the Portuguese language). In order to examine whether a change in direction would affect the strength of the RAN-reading relationship, a comparison of correlations between reading and RAN in forward and backward conditions was made. Moreover, the contribution of each RAN version for the explanation of the RAN-reading association was analyzed. Overall, RAN forward was found to be more strongly correlated with reading outcomes than RAN backward. Further, there was a unique contribution of RAN forward that went above and beyond what was explained by RAN backward. Thus, the directionality of oculomotor programming and related attentional demands, as well as the asymmetric direction of the perceptual span, seems to play a role in the explanation of the RAN-reading association. Therefore, we accepted the visual scanning hypothesis.

Our results contradict those found in the experimental literature that deals with this topic. Although Protopapas and colleagues have raised this hypothesis (2013), when comparing forward and backward RAN conditions, they unexpectedly found equally strong or even stronger correlations between RAN backward and reading fluency. Their findings led them to reject the visual scanning hypothesis and conclude that the scanning direction was irrelevant for the RAN-reading association. In the present study, we also found moderate to strong correlations regardless the RAN direction, however, significant differences were found when the two versions were compared, indicating a systematic advantage of the RAN forward version over the backward.

Methodological differences may have account for some variability between both studies. First, while we tested university students, Protopapas and colleagues tested children attending Grade 6. Expectedly, children have less years of reading experience, which means they are less experienced than highly educated adults with coordinating eye movements in the direction of reading, thereby presumably being less affected by the detrimental effects of changing the directionality of visual processing and usual perceptual span. An alternative explanation for the differences found among our studies is that the common set of mechanisms involved in RAN and reading may change through development, contributing more to fluency and less to accuracy when expertise is attained (Araujo et al., 2015; Protopapas et al., 2013). Adult readers, who have already completed all stages of reading in order to attain expertise, may rely on a set of cognitive mechanisms that involve more automatized procedures, which may as well explain the differences found between RAN forward and backward in our study, considering that automatic behaviors are known to require less attention and to be difficult to suppress once activated, indicating resistance to modification (Schneider & Shiffrin, 1977). On the other hand, children may rely on less automatic and more controlled processes, dependent on attentional clues and on the efficiency of executive control, thereby less affected by a change in the scanning direction.

Second, in our study we extended the variety of reading measures, including a diversity of reading stimuli (high-frequency words, low-frequency words and pseudowords). This diversity was expected to moderate somehow the effects of directionality on RAN-reading association. We chose to rely on word and non-word reading because it is closer to the demands of RAN when compared to text reading, which requires additional processes, such as syntactic, semantic and discourse processing (Kuperman et al., 2016). Perhaps for that reason, text reading had a reduced amount of variance (< 12%) explained by RAN in Protopapas et al.'s study. However, moderate to strong correlations were found through every dimension of reading, likely because skilled readers are less sensitive to factors such as word length and frequency (Kuperman & Van Dyke, 2011). Although we found some incongruent values (in particular regarding non-word reading, which had the lowest and highest correlation coefficients), we could not perceive a clear tendency that allow us to conclude for a differential relation of RAN with different dimensions of reading. Furthermore, differences between word a non-word correlations with RAN did not seem to rely on the RAN version (forward versus backward). Thereby, our findings suggest that in our adult sample RAN correlates strongly with reading, regardless of whether the literacy task relies primarily on phonological or orthographic processing (Araújo et al., 2015). Thereby, our findings with reading, regardless of whether the literacy task relies primarily on phonological or orthographic processing (Araújo et al., 2015). Thus, using different types of reading material did not allow us to shed some light into the differences between our own study and Protopapas et al.'s regarding the effects of RAN directionality.

Third, our study included the manipulation of the reading task format (lines versus columns), in order to overcome one of the possible limitations of Protopapas et al.'s work regarding the columnar presentation format used for their word reading task. This columnar format was thought to have prevented visual scanning to be fully shared among RAN and reading (Protopapas et al., 2013). Thus, we developed a reading task for words and non-words presented in rows (where reading was by lines and therefore closer to the visual scanning demands of RAN), to compare to an analogous reading measure, presented in a column format. Nonetheless, our results showed that the association between RAN and reading did not seem to be reliably affected by the presentation format of the reading tasks. Only pseudowords read in the column format showed significantly stronger correlations with RAN, compared to reading pseudowords in rows. However, this effect was similar across all RAN versions, so it was not moderated by RAN directionality. Our results are in line with Protopapas et al.'s findings, who did not find differences between reading task formats (although they did not used a row word reading task but a passage fluency reading task).

As mentioned above, it can be argued that because there were no systematic significant differences among the column and the row format of reading as it relates to RAN, the scanning direction could not play an important role in their association. Nevertheless, although the vertical arrangement of a column format mainly requires a vertical rather than horizontal scanning direction, it is still consistent with the top-to-down usual reading direction, thereby shared with RAN forward but not with RAN backward. Moreover, proficient readers seem to be less sensitive to superficial task features (Kuperman & Van Dyke, 2011).

Hence, and considering the supportive data found in our study, we do not consider there is strong evidence against our decision to accept the visual scanning hypothesis.

Recent studies regarding the visual scanning hypothesis contrast with our main conclusions, claiming that directionality is irrelevant for the RAN-reading relationship and for visual scanning itself (Henry, Van Dyke and Kuperman, 2018; Kuperman et al., 2016). However, their conceptualization of visual scanning was different from Protopapas et al.'s: visual scanning is defined as the ability to orchestrate rapid and sequential eye movements through visual stimuli. Thus, they hypothesized that adults who were better at coordinating eye movements during reading, were also better at coordinating eye movements during RAN, regardless of the scanning direction. To test this hypothesis, unlike our purely behavioral study, these authors used eye-tracking to measure individual variability in eye movements during text reading and some modified RAN tasks. Manipulations of RAN tasks included naming aloud, silent naming and visual inspection of letters, digits and non-nameable symbols. They tried to isolate RAN components (saccadic planning, articulation and lexical retrieval), in order to better understand the unique contribution of the oculomotor control to the correlation of RAN with passage reading. Among those manipulations, Henry et al. (2018) also compared forward and backward versions of RAN. According to authors' perspective, this comparison should not affect the efficiency of oculomotor control but will only manipulate the effects of the perceptual span (the advantage of the wider rightward perceptual span being negated in the RAN backward version). They only found a significant advantage of RAN forward condition (over backward condition) in the total viewing time of silent scanning of digits and letters. However, considering that the scanning direction did not affect performance in their pure oculomotor conditions (i.e. silent pseudo-RAN conditions where the usual items were replaced by non-nameable symbols), the researchers concluded that the possible advantage of the parafoveal preview was not an underlying cause of the RAN-reading association. They added that oculomotor control and attentional demands shared by RAN and reading were an important component of that link, although restrained to the ability to control rapid sequential eye movements and to engage and disengage visual stimuli across a page, regardless of the scanning direction.

Our results are not compatible with those found by Henry and colleagues. In line with their findings, moderate to strong correlations were found between reading and RAN backward in our study (.32 $< r <$ .62), which seems to support that a precise and fast oculomotor control is important for both directions. However, our findings revealed that directionality still plays a role in the RAN-reading association. In fact, we found significantly weaker correlations with reading when RAN was backward and, as mentioned before, the hierarchical regression analysis indicated a unique contribution (8–24%) of the forward version, that goes above and beyond the contribution of the backward version. If we consider that oculomotor control is equally important for both directions, as claimed by Henry et al., our results can be interpreted as indicative of differences in perceptual span of forward and backward RAN, convergent with the notion that skilled readers are sensitive to the availability of parafoveal information and can benefit from a wider rightward perceptual span (e.g. Veldre & Andrews, 2014; Jones et al., 2009). In this perspective, years of reading experience may have resulted in an asymmetrical perceptual span, which may explain the impact of directionality on the RAN-reading relationship in proficient readers. Thus, right-side parafoveal advantage in languages with the left-to-right direction of reading is a potential candidate to explain (at least, partially) the relationship between reading and RAN. However, our interpretations should be made with caution, considering the inconsistencies found between studies, as well as methodological differences. Further investigation is needed to clarify what may precisely underlie the visual scanning influence.

Overall, we also highlight that our results support a longitudinal association of RAN and reading that remains through adulthood, consistent with previous evidence. For instance, Van den Bos et al. (2002) found a correlation of r = .53 between word reading and alphanumeric RAN in adults with ages between 36 and 65 years old, whereas we found strong correlations (as high as r = .71) in a sample of university students, which represents the higher end of the skill continuum of reading.

One limitation of the current study is the fact that our experimental manipulation (the comparison between RAN forward and backward) does not allow us to differentiate potential processes involved in the directionality effects observed on RAN-reading association, namely the advantage of using right-side parafoveal information or the more precise control over left-to-right eye movements during visual scanning. Future research should include other experimental manipulations allowing to disentangle these components, as well as considering a possible effect of the stage of reading development on the contribution of the visual scanning for the shared variance between RAN and reading.

In sum, our results demonstrated that the directionality of oculomotor programming and attentional processing affects the strength of the relationship between RAN and reading, which remains strong through adulthood and little affected by reading tasks' superficial features, like presentation format, or assessed reading dimension. These findings support the visual scanning hypothesis proposed by Protopapas et al. (2013), which suggests that the direction of the visual scanning in an important component underlying the RAN-reading association. Although our study does not allow us to disentangle whether the effect of directionality resulted from a more precise control over left-to-right eye movements or from the right asymmetry of our visual field induced by reading, this second interpretation seems more compatible with previous studies. More research is clearly needed to shed light on this relevant topic.

As a conclusion, we highlight the importance of further investigation to understand the mechanisms underlying the RAN-reading association, not only for the theoretical contribution that such an understanding would bring, but also for the contribution in terms of intervention. Considering that RAN is related to reading along the development and across all known orthographies, uncovering the causal mechanisms of this relationship will certainly promote the development of better intervention programs to approach reading disabilities.

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Annex 1. Sociodemographic questionnaire

Questionário Sociodemográfico

Data de Nascimento: __/__/____ (__ anos) **Género:** F __ M __

Nível de escolaridade: ____ (__ anos)

Ocupação: ____

Problemas de visão	Sim ☐	Não ☐	________________
Problemas de audição	Sim ☐	Não ☐	________________
Alguma vez reprovou?	Sim ☐	Não ☐	Quando? ____________
Dificuldades gerais de aprendizagem?	Sim ☐	Não ☐	Quando? ____________
Dificuldades de leitura?	Sim ☐	Não ☐	Quando? ____________
Dificuldades de escrita?	Sim ☐	Não ☐	Quando? ____________
Beneficiou de apoio educativo?	Sim ☐	Não ☐	Quando? ____________
Tem diagnóstico formal de dislexia?	Sim ☐	Não ☐	Quando? ____________
Algum problema neurológico, psiquiátrico, ou outro relevante?	Sim ☐	Não ☐	Qual(is)? ____________

Annex 2. Adult Reading History Questionnaire

U.PORTO

FPCE FACULDADE DE PSICOLOGIA E DE CIÊNCIAS DA EDUCAÇÃO
UNIVERSIDADE DO PORTO

Questionário de História de Leitura

ARHQ de Lefly & Pennington (2000)
Versão Portuguesa de Alves & Castro (2003)
Universidade do Porto

Por favor assinale com um círculo o número que melhor descreve a sua atitude ou experiência para cada uma das seguintes questões. Se lhe parecer que a sua resposta se situa melhor entre dois números, ponha um "X" nesse local.

1. Caracterize a sua atitude para com a escola quando era criança:

Adorava a escola; era a actividade favorita				**Odiava a escola; fazia tudo para não ir**
0	1	2	3	4

---

2. Sentiu dificuldades a aprender a ler na escola primária?

Nenhumas				**Muitas**
0	1	2	3	4

---

3. Precisou de ajuda adicional para aprender a ler na escola primária?

Ajuda de: Ninguém	**Amigos**	**Professores/ pais**	**Explicadores ou aulas de apoio 1 ano**	**Explicadores ou aulas de apoio 2 anos ou mais**
0	1	2	3	4

---

4. Quando era criança, acontecia-lhe trocar a ordem das letras ou dos números?

Não				**Muitas vezes**
0	1	2	3	4

---

5. Quando era criança, teve dificuldade em aprender os nomes das letras e/ou das cores?

Não				**Muita**
0	1	2	3	4

---

6. Onde colocaria o seu nível de leitura relativamente ao dos seus colegas na escola primária?

Acima da média		**Na média**		**Abaixo da média**
0	1	2	3	4

---

7. Uma vez ou outra todos os estudantes têm de se esforçar mais. Em comparação com os seus colegas de turma, que esforço despendia para realizar os seus trabalhos?

Nada	**Menos do que a maioria**	**O mesmo que a maioria**	**Mais do que a maioria**	**Muito mais do que a maioria**
0	1	2	3	4

Participante:

8. Sentiu dificuldades nas aulas de português durante o ensino básico ou secundário?

Não, tive bons resultados	**Sim, tive algumas dificuldades**	**Sim, tive muitas dificuldades e tive fracos resultados**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

9. Actualmente, qual é a sua atitude perante a leitura?

Muito positiva — **Muito negativa**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

10. Quantas leituras faz nos tempos livres?

Muitas — **Algumas** — **Nenhumas**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

11. Como considera a sua velocidade de leitura actual relativamente à de pessoas com a mesma idade e nível de escolaridade?

Acima da média — **Na média** — **Abaixo da média**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

12. Quantas leituras faz no âmbito do seu trabalho? (No caso de não trabalhar ou estar reformado quantas leituras fazia quando trabalhava?)

Muitas — **Algumas** — **Nenhumas**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

13. Na escola primária, foi difícil aprender a escrever o português correctamente (sem erros ortográficos)?

Nada difícil — **Algo difícil** — **Muito difícil**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

14. Teve dificuldade em aprender a colocar correctamente os acentos?

Nenhuma — **Alguma** — **Muita**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

15. Actualmente, como considera a qualidade da sua escrita do ponto de vista ortográfico (sem erros ortográficos) em comparação com a de pessoas com a mesma idade e nível de escolaridade?

Acima da média — **Na média** — **Abaixo da média**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

16. Na escola sentiu dificuldades na aprendizagem de línguas estrangeiras (e.g., inglês, francês)?

Nenhumas — **Algumas** — **Muitas**

0 ________ 1 ________ 2 ________ 3 ________ 4

---

17. Repetiu algum ano por causa de insucesso escolar (não por doença)?

Não	**Estive quase a repetir**	**Repeti 1 ano**	**Repeti 2 anos**	**Repeti 3 ou mais anos**
0	1	2	3	4

18. Alguma vez sentiu dificuldade em lembrar-se dos nomes de pessoas ou de lugares?

Não				**Muitas vezes**
0	1	2	3	4

19. Tem dificuldade em lembrar-se de endereços, números de telefone, datas?

Não				**Muitas vezes**
0	1	2	3	4

20. Tem dificuldade em lembrar-se de instruções verbais complexas (e.g., indicação de um percurso)?

Não				**Muitas vezes**
0	1	2	3	4

21. Actualmente, troca a ordem das letras ou dos números quando lê ou escreve?

Não				**Muitas vezes**
0	1	2	3	4

22. Por ano, quantos livros lê nos tempos livres?

Mais de 10	**6 – 10**	**2 – 5**	**1 – 2**	**Nenhum**
0	1	2	3	4

23. Quantas revistas lê por mês?

5 ou mais	**3 – 4 regularmente**	**1 – 2 regularmente**	**1 – 2 irregularmente**	**Nenhuma**
0	1	2	3	4

24. Lê jornais diários (de segunda a sexta-feira)?

Quase todos os dias	**Uma vez por semana**	**De vez em quando**	**Raramente**	**Nunca**
0	1	2	3	4

25. Lê o jornal de domingo (ou jornais semanários)?

Leio o jornal todo	**Dou uma vista de olhos todas as semanas**	**De vez em quando**	**Raramente**	**Nunca**
0	1	2	3	4

Marque a resposta mais adequada para cada uma das questões seguintes.

26. Já procurou ajuda profissional por dificuldades relacionadas com a leitura ou a escrita?

__________Sim
__________Não
Se sim, por favor dê detalhes: ____
____
____

---

27. Tanto quanto sabe, os seus pais alguma vez referiram que tinham tido dificuldades na leitura ou na escrita?

__________Sim
__________Não
__________Não tenho a certeza
Se sim, por favor dê detalhes: ____
____
____

---

28. Tanto quanto se lembra, algum dos seus irmãos e/ou irmãs teve dificuldades com a leitura ou escrita?

__________Sim
__________Não
__________Não tenho a certeza
Se sim, por favor dê detalhes: ____
____
____

---

29. Qual é o grau académico mais elevado que detém actualmente (ou que grau de escolaridade frequenta)?

__________1º ciclo (4º ano)
__________2º ciclo (7º ano)
__________3º ciclo (9º ano)
__________Secundário
__________Bacharelato
__________Licenciatura
__________Graus mais avançados

Annex 3. Stimuli used in Reading-Columns

High-frequency words

Folha 1		Folha 2		Folha 3		Folha 4		Folha 5		Folha 6	
rico		campo		código		bancário		entidade		exército	
café		azul		estilo		riqueza		deputado		companhia	
boca		fixar		cabeça		próximo		curioso		vereador	
taxa		marco		volume		propina		capítulo		homenagem	
dedo		bispo		década		barreira		legítimo		assembleia	
fome		queda		poeta		pormenor		gabinete		aproximar	
lixo		frio		baliza		laranja		material		lisboeta	
base		global		página		romance		violento		juventude	
logo		maior		apelo		trânsito		editora		república	
luta		pensão		sábado		cenário		hipótese		personagem	
júri		triste		humano		torneio		polémico		financeiro	
belo		velho		moeda		sequência		amarelo		interesse	
fuga		sonhar		índice		tradição		favorito		governante	
vivo		pobre		figura		estúdio		novidade		testemunha	
toda		mulher		camião		reflexão		paralelo		abandono	

Low-frequency words

Folha 1		Folha 2		Folha 3		Folha 4		Folha 5		Folha 6	
rima		fénix		palato		papeira		sinusite		exéquias	
boda		polpa		ampola		quermesse		exógeno		fricativa	
pipo		distal		cólica		flácido		zaragata		barbaria	
moça		fresa		esteva		equestre		filoxera		reflexivo	
gafe		clave		xarope		limalha		raticida		exequível	
mofa		flexor		alcofa		lingueta		maremoto		soldadesca	
rala		licra		golada		equador		patavina		diagonal	
dolo		transe		devoto		declive		oxiúro		transitável	
filé		ginja		noviço		linfoide		gotícula		galvânico	
popa		cerdo		venial		sintaxe		desaforo		equilátero	
muco		pinha		bicudo		equino		vigarice		hediondez	
tala		fisga		latada		bastilha		fonético		mensurável	
siso		trufa		mamute		exausto		exonerar		imergente	
isca		grude		papiro		quíntuplo		maléfico		cambalhota	
pago		salmo		jiboia		engelhar		fazedura		pandemónio	

Pseudowords

Folha 1		Folha 2		Folha 3		Folha 4		Folha 5		Folha 6	
pama		tonsal		gíbado		fuplenga		befegado		fastinência	
bilo		firta		petafo		tasvínio		lutérigo		farnepidar	
fajo		prito		nátulo		xovaico		pebilado		anefente	
niva		funte		ritapa		fupação		pemuliar		denivação	
tivo		truga		jalira		garrima		neviante		resdornista	
vuva		jurdir		zadiba		piveibo		ponovial		tavazeiro	
gaco		panvar		tuígo		miquetão		tunuente		rasfoteiro	
bito		bralhir		pógulo		tumagem		anífimo		higulhição	
duta		binfo		locépio		cráfina		dipovado		bostilmia	
lugo		teica		nefino		bacheida		vidunado		xipavação	
faga		pazal		cítimo		aspultir		nibalija		zilhuria	
sijo		dirro		telido		docrança		indulope		befinusão	
vuso		bonsfro		jadaca		preládio		nesafabo		padispate	
lafo		dineu		tifape		berfira		agurifa		teglivante	
vade		vonsa		zefudo		insbrifo		batilude		turnirpadar	

Annex 4. Stimuli used in Reading-Lines

High-frequency words

Folha 1		ruído		Folha 2		barco		Folha 3		mensagem		Folha 4		espelho	
carro		pesquisa		estrada		crónica		vermelho		massa		conter		medo	
recado		civil		jardim		aluguer		seita		banho		depressa		grito	
mito		campo		outrora		auxiliar		inverno		treze		linha		freguesia	
cerâmica		duelo		colonial		bicicleta		sonho		permitir		pergunta		tranquilo	
feliz		acampamento		convocados		major		suspensão		surpresa		mundo		tortura	
frequência		procurar		resumo		realidade		aquém		orquestra		floresta		criança	
inocente		etnia		medicina		trabalho		coesão		arroz		pastor		demora	
milho		fixação		total		fato		cerco		estrelas		história		segredo	
encontro		grupo		distinção		proporção		roupa		televisão		sono		principal	
ferro		problema		pele		fundo		linguagem		foco		fluxo		habitação	
vida		líder		bebé		negligência		conhecer		reparação		eleitoral		museu	
copo		hospital		diferentes		reino		menor		livro		penso		carnaval	
táxi		circo		brilhante		natal		fogo		retórica		narrativa			
desilusão		pesadelo		mata		filme		discreto		vírus		negativo			
professora		presente		globo		adolescente		escrever		jornal		concurso			
greve		frota		posse		cobrança		importante		mensagem		conversa			
redor		clara		jantar		cocaína		diferença				liceu			
português		pasta		sagrado		dono		vento				exemplo			
consumidor		ramo		marginal		passa		colégio				contrato			
negro		resultado		monte				casamento				proposta			

Low-frequency words

Folha 1		jaspe		Folha 2		pesticida		Folha 3		rifão		Folha 4		escopo	
safio		filantropo		bafiento		marioneta		cataclismo		esperta		abeto		anciã	
percalço		podar		fossa		flotilha		sucessivo		cabotagem		gesso		rufia	
difusor		trejeito		pandilha		pardal		divagar		púcaro		estrado		virilha	
núbil		eczema		galgo		archote		térmita		numérico		grossura		fenda	
forasteiro		franzino		cintilante		ulmeiro		esquálido		barbearia		ranhura		desvelo	
amuo		gramínea		pastar		saguim		gaspacho		xarope		móbil		galhofa	
espremer		sabre		massagem		coxia		adenda		poluente		exumação		transido	
panfleto		cloro		cardinal		ébano		borbulha		azia		camurça		prosápia	
selha		ruela		nervo		teixo		cipreste		barrote		licitude		laxativo	
salitre		ginja		goela		grilo		banha		esquimó		delinquente		garbo	
cânfora		farnel		afixar		quezília		perplexo		droguista		petulante		açafrão	
cigarra		sifão		sarro		portal		espantalho		escuna		laxativo			
poejo		herbáceo		sonhador		galantaria		pinguim		felpa		pessimista			
bule		emulativo		elidir		senha		desfolhada				camarilha			
prego		gibão		solfejo		confim		presilha				ábaco			
espaldar		pastilha		argueiro		bucha		unguento				tremoço			
mula		maciez		birra		ardina		caranguejo				aorta			
latejo		propalar		cacifo		duna		laxativo				rotativo			
maná		zumbido		absinto				cravelha				caruncho			
fuligem		desquite		mesquinho				bemol				invólucro			
ureia				percussor				obsoleto				coche			

__Pseudopalavras__

Folha 1		rinho		**Folha 2**		clata		**Folha 3**		bringuifa		**Folha 4**		prelassoca	
clunil		flitol		tragunda		catapinha		crágila		pernhedo		lavuso		albeite	
ritanfa		priguesa		nuplenta		depeval		seranfa		tranveta		pritasino		pasco	
reguvação		ginfo		esquejado		nulbafo		mantilfuda		balaceira		gonsa		labrevar	
linogado		binuendo		reife		zanifa		presládio		jalmira		vergentilpa		caquinar	
frugo		imbralhir		mentrafa		cinalho		surailode		padislenfa		gipão		zurtra	
survalho		vobativo		bernegil		fropla		feguinal		palvir		tilbemo		dipetendo	
nistalbia		monfa		tripo		tarmaruto		hismasia		gíbafo		natredor		jigoroso	
cafanlinez		brepoldina		chuvercar		flovasca		pegivente		zegre		bardisnipo		alurdiva	
gruco		felha		sedir		gernibalgia		sorro		zenildo		nelido		celpse	
cirta		bussa		vanfim		chodim		sarrivada		pátila		limbelvo		incarfo	
sogo		esgate		galminto		dole		lano		vidunaldo		mipavação		grira	
casprense		imvalgia		xoneipa		roldresca		caxaltiça		nifelta		glopo		esbolante	
infrisbo		pavebo		nosbilgia		panho		barlo		malco		balicanha		pegulante	
rasnobeiro		vogrança		jitelpa		maprigal		xorba		mafaneiro		isgau		garrifo	
gonsfro		begor		renimenca		negibo		esbo		nirro		borfireta			
carfascão		giritento		jandal		fata		galbérfia		pósmilfra		dipornara			
fomo		sadal		maco		premitendo		gonovial		pazol		binho			
segrelho		tiscra		gasbilência				pormeguir				raca			
minfla				lirro				escrema				castucha			
bilhurgia				virpalho				pesgueto				gasbínio			

Annex 5. RAN-Digits

7	2	3	6	1	2	7	3	1	6
3	6	2	1	6	7	2	1	3	7
2	7	3	1	3	6	1	7	6	2
6	2	1	7	6	3	2	3	7	1
3	2	6	3	2	1	7	6	1	7

Annex 6. RAN-Letters

o a s d p a o s p d

s d a p d o a p s o

a o s p s d p o d a

d s p o a s a d o p

s o d p a d o a p s