Original Article

https://doi.org/10.1590/2317-6431-2022-2641en

Audiology Communication Research
ISSN 2317-6431

The contribution of rapid automatized naming with reading rate and text comprehension in Brazilian elementary school children

A contribuição da nomeação automatizada rápida para a velocidade e compreensão de leitura textual em crianças brasileiras do ensino fundamental

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ABSTRACT

Purpose: The main objective of the present study was to examine the contribution of rapid automatized naming (RAN) to reading rate and text comprehension. We also analyzed whether the performance on a rapid automatized naming task in the first year of schooling could be a predictor of the future skill in reading speed and text comprehension. **Methods**: Forty protocols with phonological processing skills assessments were analyzed, namely: rapid automatized naming, phonological awareness and phonological working memory, as well as assessment of reading rate and comprehension, carried out in 2008 and 2011, when children were respectively, in the 2nd and 5th grades of Elementary School I. **Results**: For children in 2nd grade, the RAN of objects was able to predict their performance in reading speed, whereas for children in 5th grade, the performance of RAN of letters plays such a role. In the 2nd grade, RAN contributes indirectly, through reading speed, to the performance of children in reading comprehension. In the 5th grade, among the phonological processing skills, working memory stands out for correlating significantly with reading comprehension. The reading speed of the 2nd grade was able to predict the performance of the reading speed in the 5th. grade. **Conclusion**: Such findings are important for clinical and educational practice, reinforcing that RAN is an important skill which contributes to reading rate which in turn, is important for reading comprehension

Keywods: Reading; Reading Comprehension; Elementary School; Learning; Language

RESUMO

Objetivo: o objetivo principal do presente estudo foi examinar a contribuição da nomeação automatizada rápida (NAR) para velocidade e compreensão de leitura. Analisou-se, também, se o desempenho da tarefa de nomeação automatizada rápida em ano inicial da escolaridade poderia ser preditora da habilidade ulterior em velocidade e compreensão de leitura textual. **Métodos**: foram analisados 40 protocolos das avaliações das habilidades do processamento fonológico, sendo elas: nomeação automatizada rápida, consciência fonológica e memória de trabalho fonológica, assim como avaliação da velocidade e compreensão de leitura, realizadas em 2008 e 2011, quando as crianças cursavam, respectivamente, o 2º e o 5º ano do ensino fundamental I. **Resultados**: no 2º ano, a NAR de objetos foi capaz de prever o desempenho em velocidade de leitura. Já no 5º ano, a NAR de letras assumiu tal papel. No 2º ano, a NAR contribuiu de forma indireta, por meio da velocidade de leitura, para o desempenho das crianças em compreensão leitora. Já no 5º ano, dentre as habilidades do processamento fonológico, a memória de trabalho se destacou por se correlacionar significativamente com a compreensão da leitura. A velocidade de leitura do 2º ano previu o desempenho da velocidade de leitura no 5º ano. **Conclusão**: Os achados deste estudo se mostram importantes para a prática clínica e educacional, reforçando que a NAR apresenta importante contribuição para a velocidade de leitura e esta, por sua vez, é importante para a compreensão de leitura.

Palavras-chave: Leitura; Compreensão de Leitura; Ensino Fundamental; Aprendizagem; Linguagem

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Conflict of interest: No.
Authors' contribution: SV participated in the Project design, analysis, and data interpretation, editing, and review of the intellectual content, final approval of the version to be published, and submission; JC participated, as project supervisor, in data analysis and interpretation, editing, review of the intellectual content, and final approval of the version to be published; RM participated, as project supervisor, in data analysis and interpretation, editing, review of the intellectual content, and final approval of the version to be published; ALN participated, as project supervisor, in data analysis and interpretation, editing, review of the intellectual content, and final approval of the version to be published.
Funding: Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq, Contrato número 142059/2017-0.
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Received: February 22, 2022; **Accepted:** May 15, 2022

INTRODUCTION

Reading is an extremely important skill, especially in the school environment, where learning occurs mostly through language. Automatic word recognition is among the components to achieve a skilled reading, allowing reading to develop accurately and effortlessly with proper speed[1].

In early reading development, word recognition occurs slowly. As the child advances in education and acquires reading practice, word recognition becomes faster and automatic, allowing for cognitive resources to be directed to comprehension[2].

Reading is a very complex activity that involves linguistic-cognitive skills, particularly those related to the phonological processing and fast coordination of visual processes that occur during the decoding and automatic recognition of written words[3]. A basic skill that has been strongly associated with the ability of reading is rapid automatized naming (RAN), defined over the years as the ability to name as fast as possible visually presented familiar stimuli[1-4]. The RAN assesses the lexical access speed by measuring the time that a child takes to look at the visual stimulus, recognize them, and access the meaning in the long-term memory[1].

During the tasks of RAN, the participant must name as fast and more correctly as possible a sequence of familiar visual stimuli of different types. The classic test of RAN[5] consists of the following subtests: objects, colors, numbers, and letters. Each subtest is arranged in a flashcard with five different stimuli randomly placed in ten lines. The naming must start from the left to the right, from the top to the bottom, similar to the direction of the reading process in Western alphabetic languages. Therefore, just as it occurs in reading, the visual stimulus must be identified, the phonological representation accessed, the meaning in the semantic network recognized, and the phonetic processing for the oral articulation of the word accessed[1]. Thus, it can be said that rapid automatized naming and reading are related since both demand serial processing of visual information and oral production of specific names that require to access phonological representations[6].

Van den Bos et al.[7] examined the relationship of naming speed with reading over the years by analyzing the performance of Dutch children from 8 years old until adulthood concerning tasks of RAN (objects, colors, numbers, and letters) and reading of words. They found a correlation between the naming of numbers and letters and reading over the years until adulthood. However, the correlation between the naming of objects and colors with reading decreased over time. In addition, they confirmed that the word reading speed increases with age, as well as the automatic naming speed. The authors also highlight that the relationship between reading and naming over the years occurs as a function of the naming of alphanumeric stimuli (letters and numbers) and not non-alphanumeric stimuli (objects and colors)[7].

In addition to the time of reading experience, reading performance may vary according to the spelling consistency[8]. Thus, it is interesting to learn whether the relationship between RAN and reading also influences the language consistency involved in the child's learning how to read.

The different spellings of the alphabetic base can be generally classified as transparent or opaque, according to the regularity of graphophonemic correspondences. A spelling is considered transparent when there is a consistent and regular mapping between phonemes and graphemes, such as in Spanish, Greek, and German, among other languages. In contrast, spelling can be considered opaque due to inconsistent mapping in the relationship between phonemes and graphemes, that is, the same phoneme can be represented by different graphemes and vice-versa. Thus, many irregularities are found in the spelling of words from the viewpoint of the phoneme-grapheme correspondence. French, Danish, and English, among other languages, are examples of opaque spellings[8]. Brazilian Portuguese, in turn, is considered a relatively transparent language due to the consistency of most graphophone correspondences.

The relationship between RAN and reading speed has been discussed in the literature considering the spelling particularities of the language[9]. Thus, in a transparent orthography, children reach reading accuracy in early education[8,10], and reading speed becomes an important measure to distinguish skilled from unskilled readers[1]. Therefore, RAN stands out as a strong predictor of reading speed throughout education, being more relevant than the other skills of phonological processing, like phonological awareness, for example[10].

In contrast, in orthographies considered opaque or inconsistent, the relationship between grapheme and phoneme is not so consistent implying greater difficulties for beginner readers[8]. Therefore, children exposed to opaque orthographies seem to need further reading experience to acquire effects of accuracy and speed[8]. In addition, the contribution of skills of phonological processing occurs in different proportions[11]. Generally, phonological awareness is an important skill in early reading acquisition. However, when children start to decode words accurately, the relationship between RAN and reading speed becomes stronger[1,9,,12].

Empirical evidence suggests that the RAN predicts the development of reading speed both in transparent and opaque orthographies, even when other skills of phonological processing, such as phonological awareness and phonological working memory, are inserted in the study[9,13,14].

As for studies conducted in Brazil, Alves et al.[15] highlight that the RAN of objects, letters, and numbers is correlated to oral reading speed in children with reading and writing difficulties. Mousinho et al.[16] found similar results regarding children without reading or writing difficulties[16] by analyzing the performance of 45 children in the 2nd grade concerning tasks of RAN (objects, colors, numbers, and letters), phonological awareness, phonological working memory, in addition to the reading of words (accuracy) and text (speed) and reading comprehension. They found a significant correlation between the non-alphanumeric RAN (objects and colors), alphanumeric RAN (numbers and letters), awareness of words, rhymes, and syllabic awareness and text reading speed.

Therefore, our main goal was to analyze the contribution of the RAN to reading speed and comprehension according to the children's education concerning the Brazilian Portuguese. In particular, we investigated whether the RAN directly contributes to reading comprehension or if such a relationship is mediated by reading speed.

We analyzed the children's performance in two moments of elementary school aiming to understand whether the relationship between RAN and reading speed and comprehension changes according to the gain in reading proficiency throughout education. We also analyzed whether the performance of rapid automatized naming in the early grades of education is a predictor of later skills of speed and comprehension of text reading.

Along with phonological awareness and phonological working memory, the task of rapid automatized naming composed the phonological processing[10]. Thus, to better assess the independent contribution of the RAN to reading in Brazilian Portuguese, it is worth considering its influence on the role attributed to other phonological processing skills.

METHODS

This study was carried out based on the analysis of documents available in the research project "Longitudinal monitoring of linguistic development in students from the CAp UFRJ: acting on the prevention and therapy of language disorders", approved by the Research Ethics Committee of the Neurology Institute Deolindo Couto – INDC/UFRJ, protocol 003/07. The project consisted of a yearly monitoring assessment of the development of reading skills and phonological processing of schoolchildren throughout elementary school. Schoolchildren with learning disorders could choose whether or not to participate in the intervention programs carried out in the outpatient clinic for reading and writing disorders of the speech therapy course at the university.

Selection of protocols for analysis

We analyzed 40 protocols after assessing the skills of the phonological processing and reading performed with the children during 2008 and 2011, when they attended, respectively, the 2nd and 5th grades of the first cycle of elementary school at the same reference school of federal education in Rio de Janeiro, since alphabetization, thereby with the same pedagogical proposal. We excluded from the research protocols children who presented complaints of learning difficulties or diagnosis of developmental disorders. Therefore, in both the school years the same 40 children were assessed, with a mean age of 7 years and 7 months in the 2nd grade (standard deviation (DP) = 4 months) and 10 years and 7 months in the 5th grade (DP = 4 months).

Choosing these specific levels of education allows for comparing the children's performance in the early years of formal reading acquisition and at the end of the first cycle of elementary school when they are more experienced readers. All parents signed an Informed Consent Form (ICF) agreeing to voluntarily participate in the research, protocol 003/07. The assessments were conducted individually by speech therapists and/or speech therapy undergraduates at the beginning of each school year during school hours.

Tasks selected from the protocols for analysis

Reading tasks

Oral reading speed

The schoolchildren were assessed concerning their reading skills based on narrative texts compatible with their education level. We asked the children to read the selected text aloud and the reading was timed. Reading speed was assessed based on the number of words read per minute (WPM). The selected texts contained 196 words[17] and 413 words, for the 2nd and 5th grades, respectively[18].

Oral reading comprehension

We used the same narrative texts as in the assessment of reading speed. Narrative texts were chosen because they are more frequent during childhood and the knowledge of their structure improves in the early school years. Following a single reading performed orally by the child – with a specific text to each school grade –, the tester proposed five questions referent to the comprehension of the text read. All questions were literal and had been formulated from explicit information in the text. The children answered the questions orally. The proportion of hits for the questions was calculated according to the children's education level.

Rapid automatized naming

We applied the subtests of objects (umbrella, comb, watch, scissors, and key) and letters (p, d, o, a, s) from the test of rapid automatized naming[19]. The stimuli in each of the subtests alternated forming ten sequential lines, with five stimuli in each line. Before the application, we verified whether the schoolchildren recognized each of the stimuli. Subsequently, the child was instructed to name the stimuli in sequence as fast as possible. The test was timed, and the total time of task execution was measured in seconds.

Phonological awareness

We applied the protocol elaborated by Cielo[20] by assessing the skills referent to phonological awareness regarding syllable, phoneme, and recognition of rhymes levels. The protocol of phonological awareness involved 12 tasks. Six tasks were presented on syllable level assessing similarity, synthesis, segmentation, and syllable transposition. The phoneme level involved five tasks: subtraction, identification, synthesis, segmentation, and transposition of phonemes. The recognition of rhymes was composed of only one task. The children's performance was assessed as a function of the proportion of correct answers in the set of tasks from the protocol.

Phonological working memory

The task assesses the storage in the phonological loop of working memory and consists of the repetition of pseudowords[21]. It is worth highlighting that the children were aware of repeating words that did not exist. The goal was to observe how many sound units the child could temporarily store from a sequence of speech sounds without semantic support. The task starts with monosyllables pseudowords (example: lum) and gradually increases to pseudowords containing six syllables (example: *chedizatocaro)*. Each extension of pseudowords contains five items, for a total of 30 items. The child must repeat the same pattern provided by the evaluator. The child's score was counted by the proportion of hits in the task.

RESULTS

As for the performance of the children in the 2nd and 5th grades for reading speed and comprehension – for the different skills of phonological processing –, a significant difference was found between the performance of the 2nd and 5th grades for the RAN objects and RAN letters. We also found a significant correlation between the RAN objects in the 2nd grade and RAN objects in the 5th grade (r=,58, p<,01). However, there was no significant correlation between the RAN letters in the 2nd grade and RAN letters in the 5th grade (r=,28, p=,08) (Table 1).

As for the reading skills, there was also a significant difference between the performance in the 2nd and 5th grades for reading speed, however, the same was not true for reading comprehension (Table 1). Reading speed and comprehension significantly correlated in the 2nd grade (r=,46, p<,01) but not in the 5th grade (r=,06, p=,72).

An analysis of the contribution of reading skills in the 2nd grade to the posterior performance in the 5th grade revealed that by controlling the age of the children, the reading speed in the 2nd grade correlated to the reading speed in the 5th grade (r=,70, p<,01) but not to comprehension in the 5th grade (r =,11, p =,51). In addition, there was no significance in the correlation between reading comprehension in the 2nd and 5th grades (r=,25, p=,13).

Contribution of the rapid automatized naming to reading

The contribution of the RAN to speed and comprehension of text reading, just as phonological awareness and working memory, was verified according to the education level by using partial correlation controlling the age of the children (Table 2).

In the 2nd grade, the RAN objects, RAN of letters, and phonological awareness were significantly correlated to speed and reading comprehension. There was no significant correlation between working memory and the children's reading performance.

In the 5th grade, only the RAN objects and RAN letters presented a significant correlation with reading speed, while reading comprehension had a significant correlation only with phonological working memory. None of the other skills presented a significant correlation with reading comprehension in the 5th grade.

Finally, we analyzed the contribution of the linguistic-cognitive skills assessed in the 2nd grade, particularly for the RAN objects and RAN letters, to the children's reading performance in the 5th grade. By controlling the children's age, the RAN objects, RAN letters, and phonological awareness in the 2nd grade were significantly correlated to reading speed in the 5th grade. There was no significant correlation of any of the skills of phonological processing assessed in the 2nd grade with reading comprehension in the 5th grade (Table 3).

Optimum predictors for reading speed and comprehension

The analysis of multiple regression through the backward method was aimed at analyzing whether the tasks of RAN could significantly and independently contribute to explaining the variability found in reading, according to the children's education level. We performed two analyses of multiple regression for the 2nd grade. One targeted reading speed based on the factors of age, RAN of objects, RAN of letters, and phonological awareness and the other focused on reading comprehension based on the

Table 1. Reading performance and skills of the phonological processing according to the education level

	2nd grade (n=40)		5th grade (n=40)		t(39)	p-Value
	Mean	Standard deviation	Mean	Standard deviation		
Oral Reading Speed	57.75	32.87	126.95	30.63	15.745	<.01
Reading Comprehension	0.77	0.28	0.8	0.23	0.591	0.56
RAN Object	69.45	16.99	46.05	8.67	10.637	<.01
RAN Letter	36.5	9.22	22.26	3.63	9.98	<.01
Phonological Awareness	0.76	0.14	0.95	0.05	9.755	<.01
Working Memory	0.82	0.18	0.85	0.12	1.198	0.24

Note: t = computed value of t-test; oral reading speed calculated based on the number of words read in one minute; all other skills were measured by the mean proportion of hits in the task
Subtitle: n = number of students; < = lower; RAN = rapid automatized naming, measured in seconds

Table 2. Correlation between reading and skills of phonological processing according to education level

	2nd grade		5th grade	
	Speed	Comprehension	Speed	Comprehension
Oral Reading Speed	1	0.46**	1	0.06
RAN objects	-.57**	-.48**	-.35*	0.04
RAN letters	-.55**	-.36*	-.47**	-0.19
Phonological Awareness	.35*	.55**	0.15	0.26
Working Memory	0.06	0.22	0.28	.63**

Note: *p <.05; ** ; p <.01
Subtitle: RAN = rapid automatized naming

factors of age, RAN of objects, RAN of letters, phonological awareness, and reading speed (Table 4).

The result of the analysis of regression for reading speed indicated that only the RAN objects were considered a significant predictor of reading speed in the 2nd grade, explaining 32% of the variability in the children's performance. For reading comprehension in the second analysis, the regression result suggested phonological awareness and reading speed as significant predictors, explaining 36% of the variability in the children's performance. The standardized coefficient of the analyses of regression allowed for proceeding with the analysis of pathways for the relationship between RAN objects and reading comprehension, mediated by reading speed in the 2nd grade (Figure 1).

As for the 5th grade, we performed an analysis of multiple regression only for reading speed since for reading comprehension, only the working memory showed a significant correlation. The analysis of multiple regression through the backward method for reading speed in the 5th grade was based on the factors of age, RAN objects in the 5th grade, and RAN letters in the 5th grade. RAN letters proved to be the best predictor of reading speed for children in the 5th grade, explaining 21% of performance variability (Table 5).

We performed an analysis of multiple regression to verify which of the skills assessed in the 2nd grade would be predictors of reading speed in the 5th grade based on the following factors: the age of the children in the 5th grade, RAN objects, RAN letters, phonological awareness, and reading speed. The result of the regression indicated that the age of the children in the 5th grade and reading speed in the 2nd grade were the best predictors for reading speed in the 5th grade (Table 5), explaining approximately 50% of the children's performance variability.

DISCUSSION

This research analyzed the contribution of the RAN to reading speed and comprehension throughout education seeking to learn whether it was a predictor of the children's later skills in reading speed and comprehension during the early education years. We investigated whether there is a direct contribution between RAN and reading comprehension or if such a relationship is mediated by reading speed. For such a purpose, the independent contribution of the RAN was analyzed considering the role of the other related skills of phonological processing, both to reading speed and comprehension, namely: phonological awareness and phonological working memory.

Table 3. Correlation between skills of phonological processing for the 2nd grade and reading for the 5th grade

	Reading Skills for the 5th grade	
Phonological Processing	**Speed**	**Comprehension**
2nd grade		
RAN objects	-.56**	0.06
RAN letters	-.40**	-0.11
Phonological Awareness	.35*	0.16
Working Memory	0.02	0.13

Note: *p <, 05; ** p <, 01
Subtitle: RAN = rapid automatized naming

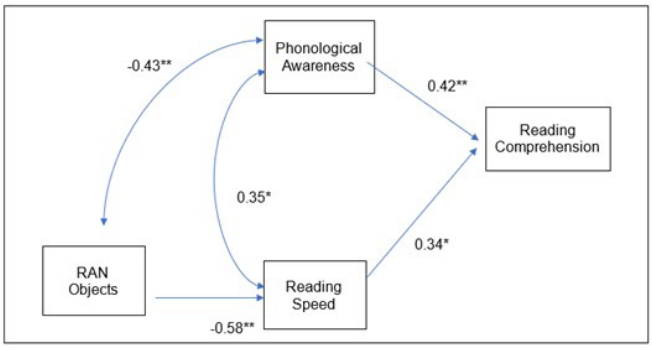

Figure 1. Path Diagram for Reading Comprehension in Grade 2
Note: * p <. 05; ** p <. 01
Subtitle: RAN = rapid automatized naming

Table 4. Predictor skills of reading performance for children in the 2nd grade

	B	SE B	β	t	p-Value
Reading speed ($R^2_{adjusted}$ = 32; (F (1.39) = 19.32, p<.01)					
RAN of objects	-1.12	.255	-0.58	-4.39	<.01
Reading comprehension ($R^2_{adjusted}$ = 36; F(2.39) = 11.83, p<.01)					
Phonological awareness	.819	.266	0.42	3.08	.004
Reading speed	.003	.001	0.34	2.45	.019

Note: $R^2_{adjusted =}$ adjusted coefficient of determination
Subtitle: F = computed value from the Analysis of Variance; B = non-standardized coefficient; SE B = standard error of B; β = standardized coefficient; t = computed value from t test; RAN = rapid automatized naming

Table 5. Predictor skills of reading performance of children in the 5th grade

	B	SE B	β	t	P-Value
Reading speed ($R^2_{adjusted}$ =.210; (F (1.39) = 11.34, p=.002)					
RAN letters in the 5th grade	-4.043	1.201	-0.48	-3.36	0.002
Reading speed ($R^2_{adjusted}$ =.498; F (2.39) = 20.35, p<.01)					
Age of the children in the 5th grade	-3.134	0.947	0.38	3.3	0.002
Reading speed in the 2nd grade	0.636	0.107	0.68	5.93	<0.01

Note: $R^2_{adjusted =}$ adjusted coefficient of determination
Subtitle: F = computed value from the Analysis of Variance; B = non-standardized coefficient; SE B = Standard error of B; β = standardized coefficient; t = computed value from t test
Caption: RAN = rapid automatized naming

The results found herein revealed that for the children in the 2nd grade of elementary school, the performance in RAN letters, RAN objects, and phonological awareness presented a significant correlation with reading speed. Thus, the faster the stimulus is named in the RAN task and the greater the ability to manipulate speech sounds, and the higher the reading speed in the 2nd grade. It could be said that, initially, a faster reading demands analyses and operations with the phonological information contained in the words, as well as the speed at which the phonological representations are accessed.

The analysis of regression pointed out the RAN objects as the skill that best predicts reading speed in the 2nd grade. We could assume that in the early reading experience, naming fast objects, that is, fast activation of semantic representation in the lexicon, favors reading speed. The automatic naming of objects requires identifying the visual stimulus, recognizing the meaning in the semantic network, and accessing the phonological representation for the planning of word oral articulation[1]. It could be discussed that the RAN objects demand conceptual processing beyond the phonological representations[22]. Thus, the information established in the children's semantic network seems to facilitate word recognition, making the reading faster.

There is evidence that the RAN objects activate the same neural circuits responsible for the visual recognition of words[23,24]. Cummine et al.[24] used functional neuroimage and found that during the naming of objects, the processing of the ventral-lexical stream is activated. It consists of a system of automatic word recognition, including the lateral and medial occipital regions, inferior and middle temporal gyri, anterior portion of superior temporal gyrus, angular gyrus, and anterior region of inferior frontal gyrus. These regions are activated both during the naming of objects and during reading, reinforcing the relationship between RAN and reading through the lexical route in the early years of learning.

Even as education advances, RAN continues to relate to reading speed[25,26]. Our results suggest that when schoolchildren presented reading greater experience, in the 5th grade, the RAN, both of letters and objects, maintained a significant correlation with reading speed. Therefore, the speed of access to phonological information remained correlated to faster reading. In the 5th grade, rapid naming maintained its predictive ability, however, the stimulus changed, and the RAN letters became the best predictor of reading speed.

Such findings can be explained by the hypothesis that both during reading and the naming of letters, very similar neural circuits are activated related to the processing of the ventral-lexical and dorsal-sublexical streams, as suggested by Cummine et al.[24]. As mentioned, the processing of the ventral-lexical stream[24] – also activated during the naming of objects – is related to word recognition and, therefore, to a lexical route of reading. In turn, the processing of the stream dorsal-sublexical[24] is involved in the integration of spelling characteristics and phonological representations of words, which includes regions like the posterior portion of the superior temporal gyrus, the supramarginal gyrus, and inferior parietal lobe, and the superior and inferior frontal gyri[24]. It could be inferred that the naming of letters as the best predictor of reading speed in the 5th grade is related to the greater reading automatization, activating the phonological and spelling processes that allow for fast reading, both of words and pseudowords[25]. Therefore, the reader acquires reading proficiency by using resources through lexical and phonological routes, thus reinforcing the longitudinal relationship between skills of RAN and reading speed since both are involved in the common neural circuits[23].

When examining the predictive role of the linguistic-cognitive skills of children in the 2nd grade for reading speed in the 5th grade, we found that the performance in reading speed was able to predict the reading speed performance in later years when children were in early education. Therefore, the children who initially presented greater reading speed tend to read with greater fluency throughout education. As the children decodify faster, they can read faster, thus tending to read more. With such an increase in the reading experience, they familiarize themselves with the visual form of words read more frequently, establishing thus a mental dictionary. Thereby, they start to visually recognize the most frequent words without needing the graphophonemic conversion, allowing for increasingly faster visual recognition of words as the education advances[27].

In this study, as it was performed with reading speed, we carried out an analysis of multiple regression to find whether the RAN predicted the performance of schoolchildren in reading comprehension. In the early learning process, when children were in the 2nd grade, the skills of phonological awareness and reading speed contributed as the best predictors of reading comprehension, in which phonological awareness explained the variability of results much more than the RAN.

The skill of phonological analysis is relevant for reading comprehension due to its influence on decoding[28]. Thus, we could assume that in the early reading experience, comprehension depends more on the accuracy skill than reading speed. Since the reading speed acquired by the child also predicts the comprehension performance and the RAN is the best predictor of reading speed, we conclude that the RAN indirectly influences reading comprehension in the 2º grade.

Karadağ et al.[29] found a similar result when examining Turkish children in the 2nd grade. The RAN had a predictive effect on reading speed, which, in turn, had a predictive effect on reading comprehension. In their study, as well as herein, reading speed had a mediator role in the relationship between RAN and reading comprehension. Thereby, we understand that the relationship between RAN and reading comprehension occurs through reading speed[29].

In the 5th grade, only phonological working memory maintained a significant correlation with reading comprehension. Thereby, the children with a greater ability of phonological storage were those who understood the text better. It is considered that as the child advances in education, the texts become longer, therefore, working memory is increasingly required to integrate the several parts of the text to establish comprehension[2]. During reading, the child temporarily stores the meaning of the sentence in the working memory while continuing to read and integrates the meaning of what has just been read with the following sentence[2]. Therefore, by reading a text, the child maintains the information selected as more important and, as the reading continues, the child also relates such information to those existing in the long-term memory, their knowledge of the world[26]. In addition, we observed that in the 5th grade, reading became more automatic, with the required intonation, allowing that cognitive resources, previously presented for basic reading skills, were redirected to reading comprehension and construction of meanings[30].

When investigating the relationship between RAN and reading skills, it is important to examine the limitations of this study. Therefore, further studies should consider them in their design.

If we consider, initially, that the reading comprehension was performed only with literal answers, which did not allow us to find a significant difference in the performance of schoolchildren in the 2nd and 5th years. Inferential answers should also be considered. Given the complexity of reading, it is important to use other comprehension measures not of offline nature, as in the case of questions and answers. The Cloze test, for example, due to its contextual nature and online assessment of comprehension, can be an interesting instrument to be included in the investigation.

Further studies should also focus on the RAN assessment. Herein, we used only the classic version of the task, however, other versions of the test of rapid naming also deserve attention.

CONCLUSION

The performance in RAN tasks can predict reading speed throughout elementary school. In the initial years, the RAN objects seem to maintain a strong relationship with reading speed, showing that the information established in the child's semantic network facilitates reading. In turn, when reading is more automatic, by the end of the first cycle of elementary school, the performance in RAN letters has a greater influence on reading speed.

Such findings are relevant for the clinical and educational practice since the knowledge of the RAN and other skills of phonological processing favor the planning of intervention strategies that benefit reading speed and comprehension for typical readers and those with reading difficulties since early education. Similar practices targeted at lexical access may become valuable learning strategies. In addition to their easy application, using RAN tasks in speech therapy and educational assessments can help identify difficulties found in the process of learning how to read, particularly in the early school years.

Acknolwedgements

Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq; Coordenação de Aperfeiçoamento de Pessoal of Nível Superior – CAPES; Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro – FAPERJ.

REFERENCES

1. Norton ES, Wolf M. Rapid automatized naming (RAN) and reading fluency: implications for understanding and treatment of reading disabilities. Annu Rev Psychol. 2012;63(1):427-52. http://dx.doi.org/10.1146/annurev-psych-120710-100431. PMid:21838545.
2. Stanovich KE. Concepts in developmental theories of reading skill: cognitive resources, automaticity, and modularity. Dev Rev. 1990;10(1):72-100. http://dx.doi.org/10.1016/0273-2297(90)90005-O.
3. LaBerge D, Samuels SJ. Toward a theory of automatic information processing in reading. Cognit Psychol. 1974;6(2):293-323. http://dx.doi.org/10.1016/0010-0285(74)90015-2.
4. Schwanenflugel PJ, Meisinger EB, Wisenbaker JM, Kuhn MR, Strauss GP, Morris RD. Becoming a fluent and automatic reader in the early elementary school years. Read Res Q. 2006;41(4):496-522. http://dx.doi.org/10.1598/RRQ.41.4.4. PMid:20072665.
5. Denckla MB, Rudel R. Rapid "Automatized" naming of pictured objects, colors, letters and numbers by normal children. Cortex. 1974;10(2):186-202. http://dx.doi.org/10.1016/S0010-9452(74)80009-2. PMid:4844470.
6. Peterson RL, Arnett AB, Pennington BF, Byrne B, Samuelsson S, Olson RK. Literacy acquisition influences children's rapid automatized naming. Dev Sci. 2018;21(3):e12589. http://dx.doi.org/10.1111/desc.12589. PMid:28812316.
7. Van den Bos KP, Zijlstra BJ, Lutje Spelberg HC. Life-span data on continuous-naming speeds of numbers, letters, colors, and pictured objects, and word-reading speed. Sci Stud Read. 2002;6(1):25-49. http://dx.doi.org/10.1207/S1532799XSSR0601_02.
8. Seymour PH, Aro M, Erskine JM. Foundation literacy acquisition in European orthographies. Br J Psychol. 2003;94(Pt 2):143-74. http://dx.doi.org/10.1348/000712603321661859. PMid:12803812.
9. Moll K, Ramus F, Bartling J, Bruder J, Kunze S, Neuhoff N, et al. Cognitive mechanisms underlying reading and spelling development in five European orthographies. Learn Instr. 2014;29:65-77. http://dx.doi.org/10.1016/j.learninstruc.2013.09.003.
10. Rodríguez C, van den Boer M, Jiménez JE, de Jong PF. Developmental changes in the relations between RAN, phonological awareness, and reading in spanish children. Sci Stud Read. 2015;19(4):1-16. http://dx.doi.org/10.1080/10888438.2015.1025271.
11. Lipka O. Reading fluency from grade 2–6: a longitudinal examination. Read Writ. 2017;30(6):1361-75. http://dx.doi.org/10.1007/s11145-017-9729-1.
12. Jesus LCD, Alves LM, Martins-Reis VDO. Quais fatores cognitivos e linguísticos influenciam o processamento fonológico em adolescentes? CoDAS. 2022;34(1):e20200158. https://doi.org/10.1590/2317-1782/20212020158.
13. Caravolas M, Lervåg A, Defior S, Seidlová Málková G, Hulme C. Different patterns, but equivalent predictors, of growth in reading in consistent and inconsistent orthographies. Psychol Sci. 2013;24(8):1398-407. http://dx.doi.org/10.1177/0956797612473122. PMid:23744876.
14. Ziegler JC, Bertrand D, Tóth D, Csépe V, Reis A, Faísca L, et al. Orthographic depth and its impact on universal predictors of reading: a cross-language investigation. Psychol Sci. 2010;21(4):551-9. http://dx.doi.org/10.1177/0956797610363406. PMid:20424101.
15. Alves D, Soares AJC, Cárnio MS. Velocidade de leitura e nomeação automática rápida em crianças com alterações de leitura e escrita. Distúrb Comun. 2012;24(1):85-9.
16. Mousinho R, Mesquita F, Leal J, Pinheiro L. Compreensão, velocidade, fluência e precisão de leitura no segundo ano do ensino fundamental. Rev Psicopedagogia. 2009;26(79):48-54.
17. Cocco MF, Hailer MA. ALP 1: análise, linguagem e pensamento: um trabalho de linguagem numa proposta socioconstrutivista. São Paulo: FTD; 1995.
18. Tavares U. Tutty o terror das calças brancas. In: Tavares U. Só não venha de calça branca: cãografia autorizada de Tutty Antonio. 3. ed. São Paulo: Saraiva; 2005. Coleção Jabuti.
19. Denckla MB, Rudel R. Rapid "Automatized" naming of pictured objects, colors, letters and numbers by normal children. Cortex. 1974;10(2):186-202. http://dx.doi.org/10.1016/S0010-9452(74)80009-2. PMid:4844470.

20. Cielo CA. Habilidades de consciência fonológica em crianças de 4 a 8 anos de idade [tese]. Porto Alegre: PUC-RGS Faculdade de Letras. Curso de Pós-Graduação em Letras; 2001.

21. Kessler TM. Estudo da memória de trabalho em pré-escolares [dissertação]. São Paulo:Universidade Federal de São Paulo, Escola Paulista de Medicina; 1997.

22. Donker M, Kroesbergen E, Slot E, Van Viersen S, De Bree E. Alphanumeric and non-alphanumeric Rapid Automatized Naming in children with reading and/or spelling difficulties and mathematical difficulties. Learn Individ Differ. 2016;47:80-7. http://dx.doi.org/10.1016/j.lindif.2015.12.011.

23. Lervåg A, Hulme C. Rapid Automatized Naming (RAN) taps a mechanism that places constraints on the development of early reading fluency. Psychol Sci. 2009;20(8):1040-8. http://dx.doi.org/10.1111/j.1467-9280.2009.02405.x. PMid:19619178.

24. Cummine J, Szepesvari E, Chouinard B, Hanif W, Georgiou GK. A functional investigation of RAN letters, digits, and objects: how similar are they? Behav Brain Res. 2014;275:157-65. http://dx.doi.org/10.1016/j.bbr.2014.08.038. PMid:25172183.

25. Araújo S, Reis A, Petersson KM, Faísca L. Rapid automatized naming and reading performance: a meta-analysis. J Educ Psychol. 2015;107(3):868-83. http://dx.doi.org/10.1037/edu0000006.

26. Peres S, Mousinho R. Avaliação de adultos com dificuldades de leitura. Rev Psicopedagogia. 2017;34(103):20-32.

27. Mousinho R, Correa J, Oliveira R. Fluência e compreensão de leitura – Linguagem escrita dos 7 aos 10 anos para educadores e pais. São Paulo: Instituto ABCD; 2019.

28. Cárnio MS, Vosgrau JS, Soares AJC. The role of phonological awareness in reading comprehension. Rev CEFAC. 2017;19(5):590-600. http://dx.doi.org/10.1590/1982-0216201619518316.

29. Karadağ Ö, Keskin HK, Arı, G. Mediatory effect of reading skill in the rapid automatized naming/reading comprehension relationship. Educ & Sci. 2019;44(197):353-66. http://dx.doi.org/10.15390/EB.2019.7684.

30. Correa J, Ramires G. Fluência de leitura: o que, por que e para que. In: Mousinho R, Alves LM, Capellini S. Dislexia: novos temas, novas perspectivas. Rio de Janeiro: Wak Editora; 2015. p. 141-9.