

Pablo Felicio Nepomuceno<sup>1</sup>  
Clara Regina Brandão de Avila<sup>1</sup>

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# Performance of students with and without reading difficulties on decoding tasks

## *Caracterização do desempenho de escolares com e sem dificuldades de leitura em tarefas de decodificação leitora*

### ABSTRACT

**Purpose:** To characterize the performance of students with and without reading difficulties in reading decoding tasks to investigate parameters that can facilitate reading assessment. **Methods:** Forty-eight school children, from 7 to 10 years old, who attended 2<sup>nd</sup> to 4<sup>th</sup> of Elementary Schoolgrades were studied. Based on their teacher's information, the children were divided into two groups: without reading difficulty (WRDG) and with reading difficulty (RDG). Thirty-six linguistic items were selected (words and pseudowords) and presented whole or segmented (letters and syllables) to assess the children's reading. The data were compared and statistically analyzed by Mann-Whitney and Friedman Tests. The hits, as well as sensitivity and specificity, were calculated. **Results:** WRDG had a better performance than RDG in all the tasks except whole pseudowords recognition. WRDG performed similarly in all the tasks. The RDG had more difficulty in reading pseudowords, particularly when presented syllable-by-syllable and letter-by-letter. Thirty-two point five proved to be a sensitive turning point: most of the children who decoded and read at least 32 items had been considered adequate by their teachers whereas most of those who did not had been classified by their teachers as having academic difficulty. **Conclusion:** The WRDG performance in decoding reading was homogeneous and better than that of the RDG. The RDG performed worse on reading segmented items, particularly on pseudowords.

### RESUMO

**Objetivo:** Caracterizar o desempenho de escolares com e sem dificuldade de leitura em tarefas de decodificação leitora para investigar parâmetros que possam auxiliar a avaliação da leitura. **Método:** Participaram 48 estudantes com idade entre 07 e 10 anos, matriculados do segundo ao quarto ano do Ensino Fundamental. A partir da indicação dos professores, os escolares foram agrupados em: grupo sem dificuldade de leitura (GSD) e grupo com dificuldade de leitura (GCD). Trinta e seis itens linguísticos foram selecionados (palavras e pseudopalavras) e apresentados inteiros, ou segmentados em sílabas e letras, para avaliar a leitura dos escolares. Os acertos foram computados. Os grupos foram comparados pelos testes de Mann-Whitney e Friedman. Sensibilidade e Especificidade foram calculadas. **Resultados:** O desempenho do GSD foi superior ao do GCD em todas as tarefas de reconhecimento dos itens, exceto no reconhecimento de pseudopalavras inteiras. O desempenho do GSD em todas as tarefas de reconhecimento foi uniforme. O GCD acertou menos no reconhecimento de pseudopalavras principalmente quando apresentadas de forma segmentada. Grande parte dos escolares que decodificaram e leram corretamente até 32 itens era do GSD, enquanto a maioria dos que não alcançaram esse resultado era do GCD. Esse valor (32,5) foi considerado o melhor ponto de corte para definir o desempenho dos escolares nas tarefas de decodificação. **Conclusão:** O desempenho do GSD foi uniforme e superior ao do GCD, em tarefas de decodificação leitora. O GCD apresentou pior desempenho na leitura dos itens segmentados, principalmente das pseudopalavras.

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#### Correspondence address:

Pablo Felicio Nepomuceno  
R. Botucatu, 802, Vila Clementino, São Paulo (SP), Brasil, CEP: 04023-900.  
E-mail: pablonepomuceno@yahoo.com.br

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Study carried out at the Núcleo de Ensino, Assistência e Pesquisa em Escrita e Leitura – NEAPEL, Department of Speech-Language Pathology and Audiology, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.

(1) Department of Speech-Language Pathology and Audiology, Universidade Federal de São Paulo – UNIFESP – São Paulo (SP), Brazil.

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## INTRODUCTION

Reading difficulties and alterations are prevalent among Brazilian students. Especially, in the early years of elementary school, issues related to decoding are commonly found. Usually, when compared with good readers, significant lower rate and accuracy values characterize the reading skills of these students<sup>(1)</sup>. Because of this reality, Brazilian studies have shown some interest in the processes and skills subjacent to reading performance, especially those related to the use of phonological and lexical routes<sup>(2-4)</sup>. The profile of cognitive skills subjacent to the performance deficit observed in students with difficulties in learning how to read and write showed damaged phonological skills, nomination skill, lexical access ability, visual discrimination, and pointed out that these deficits can be the cause of the impairment to learn the mechanisms of grapheme-to-phoneme conversion (and vice-versa), essential for reading and writing words and pseudowords<sup>(4)</sup>.

The procedures used to assess these difficulties associated to the decoding process are well known. The measurements of speed and accuracy rates in the oral reading of isolated items have guided both the evaluation at school and the clinical diagnosis of reading disorders. The recognition of written words requires the integrity of different processes that enable the reading<sup>(5)</sup> include the phonological one, which provides the initial decoding conditions performed by the phonological route, based on the speed and the accuracy to recover or to access the phonological information, on the quality of the stored phonological representation and on the operational phonological memory<sup>(5,6)</sup>; the orthographic one, which leads to the automatic recognition of words and expressions, based on the lexical competencies that enable the lexical route for reading with direct access to the meaning of the word, at the speed of phonological access to the mental lexicon<sup>(7)</sup>.

The almost exclusive use of the phonological routine for the processes of reading and recognizing written words<sup>(6,8)</sup> is frequently observed both in students attending the early grades and in those with difficulties or disorders associated to reading. In these cases, not rarely, the subjacent process to the changes in reading is associated to the processing of phonological information<sup>(7)</sup>. Therefore, the students who present decoding deficits may have more difficulty in reading, for instance, linguistic items that depend more on the processing of phonological information to be recognized, such as low frequency words and pseudowords, or they can read low frequency words as if they were pseudowords<sup>(9)</sup>. Besides these aspects, research on reading considers that other psycholinguistic characteristics, such as orthographic regularity and extension, in addition to familiarity, influences the reading decoding<sup>(4-8)</sup>.

The bad or poor reader is easily identified by the attentive teacher, whose perception may or may not be clinically confirmed<sup>(10)</sup>. For this confirmation, the first level of reading evaluation implies the measurement of parameters of reading fluency, and the best way to measure them is by applying the oral reading of isolated items with different psycholinguistic characteristics, so it is possible to obtain information on the phonological and lexical reading

routes<sup>(1,5-7,10)</sup>. Students with difficulties or changes in reading decoding should manifest phonological processing deficits in tasks that present more cognitive demand in reading by the phonological route.

However, the procedures that evaluate reading decoding consider the number of correct and incorrect answers in the recognition of words or pseudowords<sup>(5-8)</sup> being read in a minute. This form of evaluation does not always locate the difficulty, because only the mistake, and not the type of mistake, is indicated. The search for procedures that can identify and characterize the changes in reading at the reading decoding level is still necessary<sup>(10)</sup>.

This research was conducted from the hypothesis that besides the speed and accuracy of reading parameters, the changes in decoding could be analyzed by means of results obtained in tasks that require other skills involved in the process of recognizing the written item, besides the grapheme-to-phoneme conversion. Reading pseudowords triggers the same mechanism for any type of reader, and usually decreases the accuracy value, even in students with no difficulties to read<sup>(5)</sup>. Therefore, the segmented presentation of written items should increase the demand for skills associated to analysis-synthesis, memory, and lexical access when reading items of different psycholinguistic features, thus making it possible to differentiate the students who have difficulty in reading from students without difficulty in reading. Besides this hypothesis, other difficulties, which are associated to the effects caused by the different psycholinguistic features of the items presented for reading<sup>(2)</sup>, guided this research, include one defending that by reading linguistic items by the phonological route, students with difficulties should have a worse performance with items that are not so familiar or unknown. So, the performance in reading pseudowords and low familiarity words could distinguish students with and without difficulties to read.

Admitting that reading the presented items in a segmented way should overload the processing of phonological information, thus making the decoding of students with difficulties in reading even worse; this research produced software to assess reading decoding.

Besides its theoretical importance, this study is also relevant for the practice, because it consists of an assistance to identify children with difficulties in reading. Therefore, it is possible to say that this study was conducted with the objective of characterizing the performance of students with and without difficulties reading in tasks of reading decoding, thus investigating and establishing parameters of differentiation between the two groups of students, which can help identify the reading conditions and the school performance.

## METHODS

This study was performed after the approval of CEP 2092/09, the signature of the Assent Form by the Teaching Institution, and when the Informed Consent Forms were returned signed by the parents or by those in charge of the students.

Forty-eight students (including 30 girls) participated in this research, aged between 7 years old and 7 months and 10

years old and 10 months, regularly attending the second to forth grades of elementary school of a public school in São Paulo. The collection of results was performed in the second semester of the school year. According to procedures in the previous studies<sup>(1,11)</sup>, the teachers were asked to indicate students who, in comparison to their peers attending the same grade, presented difficulties in learning or reading, by observing their performance in reading tasks and analyzing the first four months of the school year. These students were not clinically assessed, and the information regarding the possible participation in recovery or therapeutic programs was not considered either. Therefore, a heterogeneous sample of students was constituted, with indications of difficulties to learn, without considering any diagnostic evaluation. These students were in the reading difficulties group (RDG), which counted on 19 participants with inferior reading performance in relation to their peers and to what was expected for their school year, according to the indication of their teachers. According to the criterion "absence of reading difficulties," the teachers indicated 29 students to participate in the without difficulties reading group (WRDG). According to their teachers, the reading performance of these students was compatible with what was expected for their school grade, in the first four months of the school year. Therefore, the project of this research was presented individually, to each teacher, who was then oriented to send in a list with the names of their participant students, identifying them as having or not having difficulty in reading. The lists were gathered after one week, once the teachers made this analysis exclusively, according to their perceptions regarding the performance of the students, without any interference from the researchers.

## Evaluation

Thirty-six randomly selected items were used to evaluate the reading skills of the students, from the categories established according to the psycholinguistic variables of lexicality (words and pseudowords), familiarity (high- and low-frequency words), and extension (dissyllable and trisyllable)<sup>(12)</sup>. The form of presentation also distinguished them, i.e., they were presented entirely, syllable-by-syllable, or letter-by-letter. Therefore, based on the presentation, three groups of 12 items were composed, being each one of them comprised of four high-frequency words, four low-frequency words, and four pseudowords. For each one of these categories, two items were dissyllable, and other two items were trisyllable. The distribution of the items was random, in each group, to be presented to the students. So, the first group presented the items entirely, the second group used the syllable-by-syllable form, and the third group used the letter-by-letter format.

In a silent and clear room, provided by the school, each student was positioned 60 cm in front of a 14 inch screen of a notebook. Afterward, they were told to "read all the words that appeared on the screen, being some of them more easily recognized, and others would not be recognized because they had been made up." Besides, they knew at the beginning that the words would be firstly presented entirely on the screen, then in smaller parts, but even so they should be read.

To present the reading items on the computer screen, a software, which is not yet patented, was used that was created in the Speech Language Department of the institution in charge of the research, with diagnostic and therapeutic objectives of reading disorders, especially associated to decoding deficits. This software was compatible with the operational system Microsoft® Windows and was developed with the programming language Visual Basic, and their font data were in Microsoft® Office Access. Its use basically consisted of the presentation of written items (letters, syllables, words, or non-words) to be read, entirely or separately, in different letters, syllables and fonts, colors, and speed. For this study, the used items were included in the software according to the order established in the protocol of this study and presented to the participants entirely, syllable-by-syllable, or letter-by-letter, with Arial font, black color, size 72, and exposure velocity of 500 ms. The exposure velocity was defined from the experiment by Nepomuceno<sup>(13)</sup>, who identified more correct answers in the reading of students from the first to the fourth years of elementary school, at a 500 ms exposure. Therefore, each item, entirely or separately, remained on the screen for 500 ms.

After explaining the possible doubts and receiving the signed Informed Consent Form, the presentation of items started. The performance of the student, with the canonical transcript of the reading, was written down in an individual protocol of answers. The total time of application of the task for each participant did not exceed ten minutes. Collection was concluded in a one-week period. After 48 evaluations, the correct answers were computed, according to item and form of presentation, and data were organized in tables for statistical analysis.

## Statistical method

Mann-Whitney and Friedman's tests were used to treat the obtained data. The Tukey's multiple comparison test was used to check for differences at the presence of significance.

The Reciever Operating Characteristic (ROC) curve analyzed each value of the total score. When this value was considered as cut-off point, the sensitivity and the specificity were calculated for each value (by the statistical criterion, the best cut-off point was the one that simultaneously maximized the sensitivity and specificity)<sup>(14)</sup>.

The statistical significance of the results was fixated at 0.05.

## RESULTS

Both intra and intergroup comparisons were conducted.

The comparisons conducted by the Mann-Whitney test shows that the performance of the WRDG students was superior to that of the RDG students in all tests involving the recognition of linguistic items ( $p \leq 0.001$ ), except in the one associated to the recognition of entire pseudowords ( $p=0.164$ ), when the two groups were similar. In this case, reading pseudowords had the lowest number of correct answers in the RDG students (Table 1). The statistical intragroup study of responses of the WRDG students, which compared the mean of correct answers

obtained in different reading situations of the linguistic items (familiarity and form of presentation of the item), did not show any differences between the performances in the tasks. This showed that the performance in this group was uniform.

In the RDG, no differences were observed in the performance concerning the mean of correct answers when comparing

the three forms of presentation of high- or low-frequency words. However, when the correct answers of reading pseudowords were analyzed, a higher mean of entire items recognized properly were observed in relation to those presented syllable-by-syllable and letter-by-letter, according to Tukey's multiple comparisons (Table 2).

**Table 1.** Recognition of linguistic items by students from the second to the forth years of elementary school, with and without reading difficulties.

		Difficulty		Mann-Whitney's test (p)	Result
		Without	With		
Entire words - High frequency	Mean	3.97	3.26	0.001*	Without>With
	Median	4	4		
	Standard-deviation	0.186	1.147		
	n	29	19		
Entire words - Low frequency	Mean	3.93	2.79	<0.001*	Without>With
	Median	4	3		
	Standard-deviation	0.258	1.182		
	n	29	19		
Entire words - Pseudowords	Mean	3.66	3.16	0.164	Without=With
	Median	4	4		
	Standard-deviation	0.67	1.214		
	n	29	19		
Entire words - Total	Mean	11.55	9.21	0.001*	Without>With
	Median	12	11		
	Standard-deviation	0.985	3.293		
	n	29	19		
Syllable by syllable - High frequency	Mean	3.9	3.16	0.003*	Without>With
	Median	4	4		
	Standard-deviation	0.31	1.167		
	n	29	19		
Syllable by syllable - Low frequency	Mean	3.97	2.68	<0.001*	Without>With
	Median	4	3		
	Standard-deviation	0.186	1.635		
	n	29	19		
Syllable by syllable - Pseudowords	Mean	3.48	2.16	<0.001*	Without>With
	Median	4	3		
	Standard-deviation	0.574	1.385		
	n	29	19		
Syllable by syllable - Total	Mean	11.34	8	<0.001*	Without>With
	Median	11	9		
	Standard-deviation	0.769	3.786		
	n	29	19		
Letter by letter - High frequency	Mean	3.86	2.89	0.001*	Without>With
	Median	4	3		
	Standard-deviation	0.351	1.286		
	n	29	19		
Letter by letter - Low frequency	Mean	3.93	2.74	<0.001*	Without>With
	Median	4	3		
	Standard-deviation	0.258	1.368		
	n	29	19		
Letter by letter - Pseudowords	Mean	3.62	2.26	0.001*	Without>With
	Median	4	3		
	Standard-deviation	0.622	1.558		
	n	29	19		
Letter by letter - Total	Mean	11.41	7.89	<0.001*	Without>With
	Median	12	9		
	Standard-deviation	0.867	3.914		
	n	29	19		
Total score	Mean	34.31	25.11	<0.001*	Without>With
	Median	35	28		
	Standard-deviation	1.834	10.582		
	n	29	19		

From the calculation of the ROC curve, the value of 32.5 was considered as the best cut-off point to define the performance presented by the two groups of this study as to the recognition of linguistic items. This means that the values referring to 32 correct answers in the recognition of the presented linguistic items can indicate the presence of alterations in reading (sensitivity of approximately 73.7%), while getting 33 or more correct answers in the recognition of the presented linguistic items can reliably predict the absence of reading difficulties (specificity of approximately 89.7%) (Table 3).

## DISCUSSION

This study analyzed the differences in the performance of RDG and WRDG students, in tasks of recognizing linguistic items presented entirely or separately, with the objective of establishing differentiation parameters between the two groups of students.

The results of the intergroup analyses (Table 1) pointed out differences between the groups, once the general performance in the recognition of words and pseudowords was better in the WRDG. These quantitative results corroborate findings in the published literature, and it was possible to characterize the inferior performance of students in the RDG, once they made more mistakes when recognizing words that were more or less familiar, presented entirely or separately<sup>(1,2,4,9,13)</sup>. The worst general performance of the RDG could also confirm

the proper identification and indication of teachers participating in the research work<sup>(1,10,14)</sup>.

The only similarity found between RDG and WRDG students was focused on the task of reading entire pseudowords, which determined the lowest mean value of correct

**Table 3.** Prediction of the best cut-off point between students from the second and forth years of elementary school, with and without reading difficulties

Positive if lower than	Sensitivity	Specificity
-1.0	0.000	1.000
3.0	0.053	1.000
8.5	0.105	1.000
13.0	0.158	1.000
17.0	0.211	1.000
19.5	0.263	1.000
23.0	0.316	1.000
26.5	0.421	1.000
27.5	0.474	1.000
28.5	0.526	1.000
30.0	0.579	0.931
31.5	0.632	0.931
32.5*	0.737	0.897
33.5	0.789	0.759
34.5	0.842	0.621
35.5	0.842	0.241
37.0	1.000	0.000

\*Best cut-off point from the statistical point of view (maximizing sensitivity and specificity together).

**Table 2.** Recognition of linguistic items by students from the second to the forth years of elementary school, with and without reading difficulties.

Reading item	Entireword	Syllable by syllable	Letter by letter	p-value*	p-value*	Result
WRDG	Mean	3.97	3.9	3.86	–	Entire=Syllables=Letters
	Median	4	4	4		
	SD	0.186	0.31	0.351		
	Mean	3.93	3.97	3.93	–	Entire=Syllables=Letters
	Median	4	4	4		
	SD	0.258	0.186	0.258		
	Mean	3.66	3.48	3.62	–	Entire=Syllables=Letters
	Median	4	4	4		
	SD	0.67	0.574	0.622		
RDG	Mean	11.55	11.34	11.41	–	Entire=Syllables=Letters
	Median	12	11	12		
	SD	0.985	0.769	0.867		
	Mean	3.26	3.16	2.89	–	Entire=Syllables=Letters
	Median	4	4	3		
	SD	1.147	1.167	1.286		
	Mean	2.79	2.68	2.74	–	Entire=Syllables=Letters
	Median	3	3	3		
	SD	1.182	1.635	1.368		
	Mean	3.16	2.16	2.26	Ent.xSyl.(p=0.005*)	Ent=xSyl.(p=0.005*)
	Median	4	3	3		
	SD	1.214	1.385	1.558		
	Mean	9.21	8	7.89	Ent.xLet. (p=0.012*)	Ent.xLet. (p=0.012*)
	Median	11	9	9		
	SD	3.293	3.786	3.914		
	Mean	3.16	2.16	2.26	Ent.xLet. (p=0.933)	Ent.xLet. (p=0.933)
	Median	4	3	3		
	SD	1.214	1.385	1.558		

\*Friedman's test; \*\* Tukey's multiple comparisons; significance level=0.05.

**Caption:** WRDG = without reading difficulties group; RDG = reading difficulties group; SD = standard deviation; Ent. = items entirely presented; Syl. = items presented syllable by syllable; Let. = items presented letter by letter

answers in the WRDG, and showed (as pointed out by the published literature) that reading unknown items requires that other resources associated to decoding should be activated, and these were used by both the groups<sup>(15,16)</sup>. However, the similarity was mostly determined by the lowest number of correct answers in the WRDG than the highest number of correct answers in the RDG. These results emphasize the important role of word recognition tests as indicators of reading accuracy, showing that activities like this can be used to confirm reading difficulties pointed out by the teacher<sup>(9,13,14)</sup>.

The intragroup analyses (Table 2) showed that the standard answers of each group present different characteristics. The performance of the WRDG students was uniform and characterized by high mean values of correct answers (and lower values of standard deviation), regardless of the form of presentation of the linguistic items. Such uniformity demonstrated that reading in the WRDG was also not affected by the psycholinguistic features of the recognized items.

On the contrary, the standard answers of the RDG students had a statistically lower performance in tasks involving the recognition of items presented separately, especially letter-by-letter and pseudowords. Even though reading low-frequency words determined the low mean value of correct answers, they were similar, regardless of the form of presentation of the item. This means that the students in RDG had difficulties to recognize this type of stimulus.

The lowest performance in reading segmented items was possibly associated to phonological processing deficits, or to the low amount of phonological subtract, once reading pseudowords requires, especially good decoding skills associated to the phonological memory and the automaticity of the phoneme-grapheme association<sup>(8)</sup>. The lack of semantic information to support the recognition of words requires good skills to process phonological information that can be synthesized at the cost of operational memory, forming a meaningless item, which should be stored in the short-term memory, until it is pronounced<sup>(17)</sup>. This reading mechanism gives up the orthographic processing or others that compose language subsystems, such as the semantic-lexicon<sup>(16)</sup>. It is important to remember that the visualization of the last segment of the item took longer to be presented, because each element (entirely or separately, letter or syllable) remained on the screen for 500 ms, which increased the demand for memory, attention, speed, and precision to access the semantic-lexical processor. So, if these skills are not adequate, it is possible to observe flaws when reading the segmented item<sup>(18)</sup>.

Hence, it sounds possible that tasks involving reading segmented pseudowords can be part of the resources to be used to rapidly and accurately identify RDG students<sup>(7,9,17)</sup>. The analysis of the results showed that the combination between linguistic items and the form of presentation enabled the distinction between the two studied groups.

In this study, another quantitative parameter could be established based on the results found after the conduction of the ROC curve. From the compatibility found between

the opinion of teachers regarding the reading skills of their students and their general performance by recognizing the presented linguistic items, it was possible to establish a cut-off point, making the division and characterization of the groups participating in the study more objective. Values lower than 32 correct answers in the recognition of the presented linguistic items can indicate the presence of alterations in reading, while giving 33 or more correct answers can reliably predict the absence of the reading difficulties. Therefore, most of the RDG students, according to their teachers, presented general performance lower than 32 correct answers in relation to those considered as being good readers. This indicated that this type of procedure can be sensitive to the reading difficulties which appear in the academic environment.

Thus, by analyzing all the results, it is possible to state that there was and there is a difference between the performance of RDG and WRDG students to recognize the linguistic items in several forms of presentation, and this ability is superior in students with no difficulties. Besides, two differentiation parameters were established to distinguish both the groups, i.e., the first parameter included the statistically inferior performance of students with reading difficulties in the recognition of segmented pseudowords, and the second parameter included the distinction of groups by means of the general performance in the activity of recognizing the linguistic items that were presented in this study.

So, parameters that aim to efficiently help the identification of unfavorable conditions for learning how to read and school performance were shown in this study. However, maintaining the order of the items, being the same for all the participants (started by whole words), may have interfered with the answers, improving the students' reading skills. Because the ceiling effect was observed for some stimuli, it is possible to consider that the use of different lists of stimuli or different time exposure of the written items would show results that could not be foreseen.

## CONCLUSION

The performance of WRDG students in a reading decoding task was superior to that of RDG students identified by the teachers. While the performance of WRDG students was uniform, regardless of the linguistic item to be recognized, compared with the RDG students, who had a worse performance when segmented items were recognized, especially pseudowords. Values inferior to 32 correct answers were established as a quantitative parameter for this reading procedure, to identify the presence of changes in reading decoding.

So, it was possible to establish both quantitative and qualitative parameters to assist the identification of reading difficulties in the studied group.

\*PFN was in charge of data collection, formatting, and analysis as well as writing the manuscript; CRBA was responsible for the project and study design, as well as general orientation of the stages of execution and elaboration of the manuscript.

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