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Phonological awareness, rapid automatized naming, and reading of functionally illiterate adults

Consciência fonológica, nomeação automática rápida e leitura em adultos analfabetos funcionais

Keywords

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Descritores

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ABSTRACT

Purpose: The study's purpose is to describe the cognitive profile of a sample of functionally illiterate individuals in reading, phonological awareness (PA) and rapid automatized naming (RAN), as well as to correlate the performance of these tasks. Moreover, it sought to understand how the performances in PA and RAN predict results in reading of words and pseudowords. **Methods:** 23 functionally illiterate adults were assessed for intelligence, reading, PA and RAN tasks. **Results:** Participants showed difficulties in PA, performing poorly in tasks involving phoneme analysis and manipulation. In RAN, they found it easier to name alphanumeric items. Regarding reading, they presented difficulties in phonological processing, with errors caused by phonological exchange. Correlation analyses indicated that reading presented higher correlations with RAN than PA. Finally, a regression analysis indicated that performance in RAN can account for more than half of participants' reading results. **Conclusion:** In general, the profile of functionally illiterate adults presents impairment in the abilities assessed that are more evident in PA at phoneme levels as well as in naming of non-alphanumeric items. Moreover, the results in RAN explain those in word and pseudowords reading better than the results in PA.

RESUMO

Objetivo: O presente estudo tem como objetivo descrever o perfil de adultos analfabetos funcionais em tarefas de leitura, consciência fonológica (CF), e nomeação automática rápida (NAR); bem como correlacionar o desempenho dessas tarefas. Além disso, buscou-se compreender quanto que o desempenho em CF e NAR predizem o resultado em leitura de palavras e pseudopalavras. **Método:** Foram avaliados 23 adultos analfabetos funcionais em tarefas de inteligência, leitura, CF e NAR. **Resultados:** Os participantes apresentaram dificuldades em CF, tendo pobre desempenho em tarefas que envolviam análise e manipulação de fonemas. Em NAR, apresentaram maior facilidade na nomeação de itens alfanuméricos. Em relação à leitura, houve dificuldades no processamento fonológico, apresentando erros por troca fonológica. Análises de correlação indicaram que a leitura apresentou maiores correlações com NAR do que com CF. Por fim, a análise de regressão indicou que o desempenho em NAR é capaz de explicar mais da metade do resultado em leitura dos participantes. **Conclusão:** De modo geral, o perfil dos adultos analfabetos funcionais se caracteriza por apresentar prejuízos nas habilidades avaliadas, sendo esses prejuízos mais evidentes em CF ao nível dos fonemas, bem como na nomeação de itens não-alfanuméricos. Além disso, os resultados em NAR explicam melhor os resultados de leitura de palavras e pseudopalavras do que os resultados em CF.

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INTRODUCTION

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), illiteracy is defined as the inability to read or write a simple statement related to one's daily life: 14% of the world's population over 15 years old is unable to read simple texts⁽¹⁾. In Brazil, data from 2018 indicate that 11.3 million adults (6.8% of the population) are illiterate⁽²⁾. However, this rate is even higher when functionally illiterate people are considered.

Functional illiteracy refers to the inability to understand, use and judge information contained in written materials in current use to achieve objectives, expand knowledge and participate in society⁽³⁾. In Brazil, about 29% of the adult population can be classified as functionally illiterate, that is, they have difficulties using reading and writing in everyday life situations, such as reading a poster⁽³⁾. Such prevalence studies are important to assess the economic and social impacts of the absence of proficient reading. However, these findings are not very clear about the different cognitive and linguistic profiles of this population. For example, it is still unclear whether part of the reading difficulties observed in this population is related to changes in phonological processing, as observed in studies with children.

Phonological processing refers to the use of phonological information in the processing of oral and written language. This ability has three main components: phonological awareness, assessed by tasks such as adding, deleting and isolating sounds of a word; lexical access to the phonological code, evaluated by rapid automatized naming tasks; and, finally, phonological working memory, assessed by tasks that involve storage and manipulation of phonological information for a short period⁽⁴⁾. These components correlate independently (but integrated) with reading performance, and changes in these skills impact reading acquisition and performance⁽⁵⁾. However, phonological awareness and rapid automatized naming have a greater impact on reading acquisition, as well as greater correlations with reading difficulties⁽⁶⁾.

Phonological awareness (PA) is the ability to identify and manipulate segments of speech sounds. This ability is related to phonological decoding, that is, the mapping of oral language and its spelling⁽⁶⁾. Rapid automatized naming (RAN) is the ability to name a series of familiar visual stimuli more quickly and accurately, which can be non-alphanumeric (usually colors or objects) or alphanumeric (usually letters or numbers)⁽⁶⁾. Total naming time is interpreted as an indication of automation by which visual stimuli and their phonological codes are integrated, retrieved and named⁽⁶⁾. Adults with poor reading skills have deficits in the two skills mentioned.

Regarding PA, illiterate adults have difficulties mainly in terms of phoneme awareness, which is related to low reading skills^(7,8). Thus, they perform worse in tasks involving adding and subtracting initial phonemes of words and pseudowords when compared to late literate adults, indicating that the ability to explicitly deal with phonemic units does not develop spontaneously, but is dependent on reading learning⁽⁸⁾. However, this difficulty is not seen in tasks that involve detection of syllables and rhymes, indicating that sensitivity to rhyme and

syllable analysis can develop to some extent in the absence of the experience normally provided by reading instruction⁽⁸⁾. These results are supported by evidence from experimental studies, which investigated the effects of interventions in reading with a focus on teaching correspondence between graphemes and phonemes^(7,9,10). Thus, adults who learn to read or improve their reading level have greater phonological awareness skills at the phoneme level.

Regarding RAN, few studies have investigated the relationship between naming and reading in functional illiterate adults. In one of these studies⁽¹¹⁾, illiterate adults, late literate adults and adults who were literate as children were evaluated. Thus, illiterate adults took longer to name items than the other two groups of adults. In addition, the two groups of literate adults did not differ from each other. These results suggest that learning to read, regardless of education or literacy age, facilitates lexical access. This specific facilitating effect cannot be attributed to general education, but is a consequence of literacy. Thus, learning to read strengthens interconnections between phonological and orthographic representations, promoting a more efficient recovery of words, as reflected in the better performance of the groups of readers over the illiterate⁽¹¹⁾. Also, correlations are found between RAN time with word reading and text comprehension in functional illiterate adults^(12,13). Bearing in mind that the condition of functional illiteracy impacts economic, social and cognitive development, further studies are needed to understand this phenomenon. Thus, the present study aims to describe the profile of functionally illiterate adults in reading, phonological awareness, and rapid automatized naming tasks, as well as to correlate the performance of these tasks. In addition, we sought to understand how much the performance in phonological awareness and rapid automatized naming predict the result in reading words and pseudowords.

METHODS

Participants were informed about the objectives and methods of the study and only those who agreed and signed the Informed Consent Form (ICF) participated. The ICF was read aloud to each participant and any doubts were clarified by the researcher. The study was submitted to and approved by the University's Ethics Committee (CAAE: 55505816.4.0000.0084; report: 1,559,697; date: 25/05/2016).

Participants

Participants were recruited from a school of Literacy and Education for Youth and Adults [Alfabetização e Educação de Jovens e Adultos – AEJA] in the central region of the city of São Paulo and in a cleaning company that provides services to the university.

The sample consisted of 23 adults (14 women) with incomplete elementary education and reading difficulties. The age of participants varied between 18 and 60 years, ($M=41.61$; $SD=9.96$), thus characterizing a representative sample of AEJA students⁽¹⁴⁾.

Adults who did not get all the items right in the Competence Test for Reading Words and Pseudowords⁽¹⁵⁾ were included, and

the maximum score in this test corresponds to students in the first year of Elementary School II. Thus, participants who got the 70 items right were excluded from the study.

Instruments

Intelligence assessment

The Wechsler Abbreviated Scale of Intelligence - WASI briefly evaluates intellectual ability through 4 subtests: vocabulary, similarities, block design and matrix reasoning. The subtests evaluate cognitive domains such as verbal knowledge, visual information processing, spatial and non-verbal reasoning, fluid and crystallized intelligence⁽¹⁶⁾, and make it possible to estimate the total, verbal and execution IQs. The scale was applied and corrected by a psychologist.

Reading level assessment

Word and Pseudoword Reading Competence Test (WPRCT): Assesses the skill of silent reading of words and pseudowords. It consists of 78 items, of which the first eight are for training. Each item consists of a picture and a word or pseudoword written below, and the person must indicate whether the correspondence between word and picture is correct or incorrect. Items are divided into the following types: 1) regular correct words (RC), such as FAIRY under the figure of a fairy; 2) irregular correct words (IC), such as TAXI, under the figure of a taxi; 3) words with semantic exchanges (ES), such as TRAIN, under the figure of a bus; 4) homophonic pseudowords (HP), like BYRD under the figure of a bird; 5) pseudowords with visual changes (VC), such as HAED, under the figure of a head; 6) pseudowords with phonological exchanges (PE), such as KANCAROO under the figure of a kangaroo; 7) strange pseudowords (SP), such as RASSUNO under the figure of a hand⁽¹⁵⁾. The number of correct answers was considered, with 70 being the maximum total score and 10 being the maximum number of correct answers for each of the 7 subtests.

Word Reading Test and Isolated Pseudowords: The test was developed for the present study from the list of words and pseudowords prepared by Lukasova⁽¹⁷⁾ and was composed of a list of words and a list of pseudowords with 36 items each. Words were selected according to frequency (high and low frequency), length (short and long) and regularity (regular, rule and irregular). Each item was presented sequentially and the participant was asked to read it out loud. The answers were recorded in audio files and correction was carried out later, with the reading of the item being correct or not. Thus, the score on each list ranged from 0 to 36.

Text Reading Test: Formed by 12 texts with an increasing number of words, but with an adequate degree of legibility for the first years of Elementary School, calculated using the Flesch index⁽¹⁸⁾. The 12 texts were divided into three blocks of four texts each, depending on the length: block 1) texts with 25 words on average and a Flesch Index of 85.17; block 2) texts with 45 words on average and a Flesch Index of 81.4; and block 3) 116 words on average per text and Flesch Index of 85.17.

The texts were constructed by the authors to be read aloud. In order to assess comprehension, the subject answered three literal questions related to each of the texts, in which answers were explicitly presented. For example, in a text whose theme was "The goose that laid golden eggs," one of the questions was "What kind of eggs did the goose lay?", where one point was assigned for correct answers and zero for incorrect answers. If all three questions in the text were incorrectly answered, application was interrupted to avoid potential discomfort for the participants. The score ranged from 0 to 36 points.

Oral language assessment

Phonological Awareness Test by Oral Production (PAT): Assesses the participant's ability to manipulate speech sounds, orally expressing the result of the manipulation. It has ten subtests: syllabic synthesis and segmentation, phonemic synthesis and segmentation, judgment of rhymes and alliterations, syllabic and phonemic manipulation and syllabic and phonemic transposition. Two variables were also created: Syllabic Activities, which is the sum of the four syllabic subtests, and Phonemic Activities, which is the sum of the four phonemic subtests. The following scoring criteria were considered for the analyses: total gross points, that is, the number of correct answers in all subtests, ranging from 0 to 40; raw points in each subtest, ranging from 0 to 4; finally, gross points of Syllabic and Phonemic Activities, ranging from 0 to 16 points each⁽¹⁹⁾.

Rapid Automatized Naming Test (RAN): RAN is administered individually to estimate the ability to see a symbol and name it accurately and quickly. The test consists of four subtests: colors, objects, letters and numbers. Stimuli are repeated randomly 10 times in each of the five lines, totaling 50 stimuli per board. The subject should name each item as quickly as possible without making mistakes. The total time of appointment (in seconds) for each of the boards was recorded. In addition to time per board, the following measures were recorded: RAN Total, which is the average time for all four subtests; RAN Non-Alphanumeric, which is the average time in the Colors and Objects subtests; and RAN Alphanumeric, which is the average time in the Letters and Numbers subtests⁽²⁰⁾.

Procedures

Two individual meetings were held with each participant. In the first meeting, after signing the ICF, the WASI, WPRCT, Word Reading Test and Isolated Pseudowords and PAT were applied. A week later, at the second meeting, RAN and the Text Reading Test were applied. Each meeting lasted an average of 75 minutes.

Analysis of results

Descriptive statistical analyses were performed, reporting the mean, standard deviation and the minimum and maximum values in each of the studied measures. Repeated measures ANOVA were conducted to verify existence of a difference between the correct answers in each type of WPRCT item. T-tests for paired samples were conducted to compare differences in reading

between words and pseudowords in the Word and Pseudoword Reading Test, as well as to verify differences between phonemic and syllabic activities in PAT and the alphanumeric and non-alphanumeric items of RAN. In addition, Pearson correlations were conducted between performance in phonological awareness and rapid automatized naming with the results of tests involving reading. Finally, hierarchical regression analysis using the *Enter* method was conducted, to verify the effect of the total score of RAN, PAT and age on the results in reading in the WPRCT. A significance level of 5% was established for all tests. Statistical analyses were performed using the IBM SPSS Statistics version 22 program.

RESULTS

Assessment of the intelligence level, carried out by WASI, indicated that participants had an average total IQ of 68.87 ($SD=11.81$), which is classified as extremely low. The below-average performance was also observed in the results of the Execution IQ ($M=73.04$; $SD=13.64$) and the Verbal IQ tests ($M=70.91$; $SD=10.92$). Also, 50% or more of the participants are in the extremely low range of intelligence rating (IQ below 69).

In order to compare the participants' performance with the average of each school year, participants' gross scores were analyzed based on the WPRCT normative data for elementary school students. In this way, the gross score of an adult participant was compared with the average score for each school year of children, identifying the elementary school grade whose performance was compatible. Table 1 shows the gross points obtained in each type of item, as well as for the total score in the WPRCT.

Thus, 19 participants (82.6%) had a performance similar to that of students in the fifth year of elementary school; two participants (8.7%) showed performance similar to that of fourth-year students; one participant (4.3%) had a performance equivalent to that of third-year students; finally, one (4.3%) participant had a performance comparable to that of second-year students. To investigate the existence of differences between the mean of correct answers in each type of item in the WPRCT, repeated measures ANOVA was conducted. Results indicate significant differences between the items ($F(2,65)=7.425$; $p<0.001$; $\eta_p^2=0.252$). *Post hoc* Bonferroni analyses show that the performance of the participants in PN was lower than that in RC, SN and SP.

In the Word and Pseudoword Reading Test, t-test for paired samples indicated a higher rate of correctness in words than in pseudowords ($t(21)=9.09$, $p < 0.001$). Table 2 presents the results of participants regarding correct answers in the Word and Pseudoword Reading Test, as well as the total number of correct answers in the comprehension questions of the Text Reading Test. Only one participant was unable to read any word or pseudoword from the list. In addition, only two participants were unable to read any of the texts in Block 1.

In PAT, the t-test for paired samples indicated greater difficulty in phonemic activities than in syllabic ones ($t(22)=13.23$; $p < 0.001$). For RAN, alphanumeric naming time was shorter than that for non-alphanumeric items ($t(22)=9.87$; $p < 0.001$). Considering that RAN is an instrument that aims to assess the RAN ability of children, the participants' results were compared

with the normative data of the highest age range available in the test manual, that is, 9 years and 11 months⁽²⁰⁾. In general, adults performed better than children in each subtest. In Colors, 75.1% of the participants had an above-average result; in Objects, 87.7% were above average; in Letters, 62.8%; finally, in Numbers, 71.1% were above the average for children. Table 3 presents the descriptive statistics for PAT and RAN.

In general, scores in PAT and RAN correlated significantly with the various reading measures, and these correlations had an effect size that varied between medium ($r > 0.30$) and large ($r > 0.50$). More importantly, it is possible to observe that the measures of PAT and RAN correlated in different ways with the reading tests. RAN Alphanumeric was the variable that showed the highest correlations with all reading measures. The Text Reading Test (comprehension) showed stronger correlations with RAN than with PAT. And in the sample studied, Phonemic PAT was the measure that had the least correlation with reading. Table 4 shows the correlations between the two tests.

Finally, an hierarchical regression analysis using the *Enter* method was conducted to verify the effect of the total score of RAN, PAT and age on the WPRCT reading results. Analyses suggest the existence of two models. In the first model, the

Table 1. Descriptive statistics on the performance of participants in the WPRCT, considering number of correct answers in each type of item and the total

| | Average | Standard Deviation | Minimum | Maximum |
|-----------------------------|---------|--------------------|---------|---------|
| WPRCT Total (Max=70) | 61.91 | 6.89 | 41 | 69 |
| WPRCT RC (Max=10) | 9.39 | 0.72 | 8 | 10 |
| WPRCT IC (Max=10) | 9.04 | 1.14 | 6 | 10 |
| WPRCT SN (Max=10) | 9.26 | 1.01 | 6 | 10 |
| WPRCT VN (Max=10) | 8.52 | 1.53 | 5 | 10 |
| WPRCT PN (Max=10) | 7.65 | 2.20 | 2 | 10 |
| WPRCT HP (Max=10) | 8.26 | 2.26 | 3 | 10 |
| WPRCT SP (Max=10) | 9.52 | 1.31 | 4 | 10 |

Caption: WPRCT: Word and Pseudoword Competence Test; RC: Regular Correct Word; IC: Irregular Correct Word; SN: Pseudoword Semantic Neighbor; VN: Pseudoword Visual Neighbor; PN: Pseudoword Phonological Neighbor; HP: Homophonic pseudoword; SP: Strange pseudoword

Table 2. Descriptive statistics of participants' performance in the Word and Pseudoword Reading Test (total of correct answers) and Text Reading Test (total of correct answers for comprehension questions)

| | Average | Standard Deviation | Minimum | Maximum |
|---|---------|--------------------|---------|---------|
| Word Reading (Hits, max=36) | 29.73 | 8.54 | 0 | 36 |
| Reading Pseudowords (Hits, max=36) | 21.50 | 8.84 | 0 | 32 |
| Reading Texts (total hits, Max=36) | 24.00 | 10.02 | 0 | 36 |

performance in RAN Total explains 56% of the variance in WPRCT. The second model, which includes PAT performance and age variation, did not indicate any increase in WPRCT variance, demonstrating that in the studied sample the Total PAT and age variables did not contribute to estimating the test score. The two models showed significance under 0.001. Table 5 presents the regression results.

DISCUSSION

The present study aimed to describe the performance profile of a sample of functionally illiterate adults in tasks of phonological awareness, rapid automatized naming and reading. It also aimed

to correlate performance in phonological awareness and rapid automatized naming with the results of reading tests. Finally, the study sought to understand how performance in phonological awareness and rapid automatized naming predict the result in reading words and pseudowords.

Initially, the intelligence level assessment indicated that the group's average performance can be classified as extremely low. This result was expected, given that formal schooling, educational level and years of schooling are correlated with performance in intelligence tests^(21,22). In fact, all study participants had poor formal schooling, as they had left school at the elementary level as children and were in the process of resuming their studies. In this sense, Yassuda and collaborators⁽²²⁾ assessed the intelligence

Table 3. Descriptive statistics of participants' performance in PAT (total number of correct answers) and RAN (time of appointment, in seconds)

| | Average | Standard Deviation | Minimum | Maximum |
|-------------------------------------|---------|--------------------|---------|---------|
| PAT Total (Max=40) | 26.09 | 6.5 | 13.00 | 39.00 |
| PAT Rhyme (Max=4) | 3.3 | 0.97 | 1.00 | 4.00 |
| PAT Alliteration (Max=4) | 3.52 | 0.73 | 2.00 | 4.00 |
| PAT Syllabic Syn. (Max=4) | 4.00 | 0.00 | 4.00 | 4.00 |
| PAT Syllabic Seg. (Max=4) | 3.74 | 0.61 | 2.00 | 4.00 |
| PAT Syllabic Mani. (Max=4) | 3.48 | 0.73 | 2.00 | 4.00 |
| PAT Syllabic Transp. (Max=4) | 2.65 | 1.43 | 0.00 | 4.00 |
| PAT Phonemic Syn. (Max=4) | 1.35 | 0.98 | 0.00 | 3.00 |
| PAT Phonemic Seg. (Max=4) | 0.52 | 1.16 | 0.00 | 4.00 |
| PAT Phonemic Mani. (Max=4) | 2.39 | 1.53 | 0.00 | 4.00 |
| PAT Phonemic Transp. (Max=4) | 1.13 | 1.66 | 0.00 | 4.00 |
| PAT Syllabic Activ. (Max=16) | 13.86 | 2.26 | 9.00 | 16.00 |
| PAT Phonemic Activ. (Max=16) | 5.39 | 3.93 | 1.00 | 15.00 |
| RAN Total | 32.32 | 7.44 | 21.40 | 48.57 |
| RAN Colors | 40.06 | 10.28 | 27.60 | 64.60 |
| RAN Objects | 34.93 | 8.55 | 20.37 | 60.23 |
| RAN Letters | 26.99 | 8.75 | 14.13 | 49.93 |
| RAN Numbers | 27.29 | 6.48 | 16.90 | 42.87 |
| RAN Non-alphanumeric | 37.49 | 8.40 | 26.22 | 54.57 |
| RAN Alphanumeric | 27.14 | 7.27 | 15.52 | 43.05 |

Caption: PAT: Phonological Awareness Test by Oral Production; RAN: Rapid Automatized Naming Test

Table 4. Correlation between PAT (Total, Syllabic and Phonemic) and RAN (Total, Non-Alphanumeric and Alphanumeric) and reading tests

| | PAT Total | PAT Syllabic | PAT Phonemic | RAN Total | RAN Non-Alphanumeric | RAN Alphanumeric |
|-------------------------------------|-----------|--------------|--------------|-----------|----------------------|------------------|
| WPRCT Total | 0.647** | 0.538** | 0.530** | -0.765** | -0.649** | -0.816** |
| Word Reading | 0.565** | 0.599** | 0.346 | -0.715** | -0.619** | -0.749** |
| Pseudo reading | 0.744** | 0.702** | 0.537** | -0.790** | -0.727** | -0.778** |
| Text Reading (comprehension) | 0.427* | 0.405 | 0.303 | -0.704** | -0.569** | -0.783** |

*Correlation is significant at the 0.05 level **Correlation is significant at the 0.01 level **Caption:** PAT: Phonological Awareness Test by Oral Production; RAN: Rapid Automatized Naming Test; WPRCT: Word and Pseudoword Competence Test

Table 5. Analysis of hierarchical regression of performance in WPRCT and regression coefficients of RAN Total, PAT Total and Age

| Model | β | t | p | R ² | Adjusted R ² | |
|-------|-----------|--------|--------|----------------|-------------------------|------|
| 1 | | | | | | |
| | RAN Total | -0.765 | -5.440 | < 0.001 | 0.58 | 0.56 |
| 2 | | | | | | |
| | RAN Total | -0.517 | -2.255 | 0.036 | | |
| | PAT Total | 0.250 | 1.186 | 0.250 | 0.62 | 0.56 |
| | Age | 0.162 | 1.014 | 0.323 | | |

Caption: PAT: Phonological Awareness Test by Oral Production; RAN: Rapid Automatized Naming Test; β : parameters of the regression model t; t test; p: significance; R²: value that the independent variable explains the variations in the dependent variable; Adjusted R²: R² value associated with residuals analysis

of three groups of adults with different levels of education and observed that the group with the lowest level of education was the one with the worst performance in the Wechsler Adult Intelligence Scale – WAIS-R. Thus, they suggest that intelligence measures are strongly influenced by educational level and years of schooling. In order to assess the impact of learning to read on the development of intelligence, Landgraf and collaborators⁽²³⁾ assessed the crystallized and fluid intelligence of illiterate adults before and after a year of literacy classes. Results showed that learning to read promoted an improvement in crystallized intelligence related to educational and socio-cultural contexts, but not to fluid intelligence, which is related to the ability to find solutions to complex problems in new situations. However, the intelligence assessment of functionally illiterate adults should be analyzed sparingly, since a good part of the instruments require linguistic mastery, as their application involves items of a verbal nature.

There is a lack of reading and writing assessment tools developed specifically for adults with low reading skills. Thus, use of instruments developed for children can be an alternative, since they have less complexity and, generally, less time of application, which ends up being less frustrating for the participants evaluated⁽²⁴⁾. Thus, the WPRCT was developed based on identification of reading strategies and can be used for assessing adults. The present study observed that the general performance of participants was similar to that of children in the fifth year of elementary school. Type FV items (pseudowords with phonological changes) were those with the lowest correctness marks, which may indicate a lack of recourse to the orthographic lexicon, but with the aggravation of additional difficulties in the phonological processing itself during reading. This result raises the hypothesis that part of the difficulties found in functionally illiterate adults can be explained by the impaired development of the alphabetical stage and the phonological reading path⁽¹⁵⁾. A similar pattern of responses has been found in children with dyslexia, in which they perform worse in reading pseudowords with phonological changes^(25,26). In short, even though it was developed for children, WPRCT proved useful for the evaluation of functionally illiterate adults, indicating difficulty in phonological processing.

One of the metalinguistic skills related to learning and reading performance is phonological awareness⁽⁶⁾. In this sense, greater difficulties were observed in phonemic activities than in syllabic ones. Studies conducted with illiterate adults and functionally illiterate adults show this same pattern⁽⁷⁻¹⁰⁾. Evidence suggests that this ability develops from the largest to the smallest linguistic units. Thus, early forms of phonological awareness (for example, syllable awareness, alliteration and rhyme) develop without explicit teaching and before learning to read⁽²⁷⁾. The ability to deal explicitly with phonemic units does not develop spontaneously, being dependent on learning and reading performance⁽⁸⁾. As adults learn to read or improve their reading level, performance in phonological awareness at the phoneme level also improves. The relationship between phoneme awareness and reading is bidirectional, that is, the reading experience is not only influenced by phonological awareness performance at the phoneme level, but also influences it, indicating co-dependency between these skills⁽²⁸⁾. The results

of the present study confirm this evidence, since the sample of functionally illiterate adults showed poor performance in phoneme analysis and segmentation, even though the instrument used to assess PA was developed for children and, theoretically, presents less difficulty. Thus, it is possible to conjecture that the low performance of the functionally illiterate individuals in phonemic tasks may have been influenced by their low performance and little experience with reading.

Another skill related to reading performance is rapid automatized naming. In general, the average time of appointment was shorter than that of children aged 9 years and 11 months in all subtests, indicating their better performance in the task. These results agree partially with the study by Corrêa⁽²⁹⁾, which observed Brazilian adults being literate late and had their performance in RAN tasks compared to children matched by reading level. Adults in the literacy process had a superior performance only regarding time for naming objects and digits, while their performance in letters and colors was similar to that of children. Similar results were found in a study with functionally illiterate German individuals, who had their linguistic, cognitive and numeric skills assessed and compared with normative data from studies with children. The functionally illiterate individuals were slower than children aged 5 to 8 in a quick assignment task⁽²⁴⁾. Although the present study did not make any comparison between groups of children and adults, it can be said that the performance of functionally illiterate adults in all subtests was superior to that of children who participated in the RAN standardization study. A limitation of the study was that it did not compare performance of participants in rapid automatized naming with a sample of fully literate adults. Still, regarding the characterization of the participants' performance, there is a better performance in alphanumeric items than in non-alphanumeric items. A possible hypothesis to explain this discrepancy is that, regardless of reading level, adults use much more numerical representations in their daily lives (e.g., when handling money) than representations of colors and objects.

As for the correlation analysis, it appears that performance in PA and RAN is correlated with the various reading measures. However, it was observed that naming of alphanumeric items was the one that correlated most strongly with reading, especially reading and understanding of texts. This indicates that, for the population of functionally illiterate adults, rapid automatized naming appears to be a skill that relates more to reading performance.

This is also verified in the results of the regression analysis, considering that the total performance in RAN was responsible for explaining 56% of participants' performance in reading words and pseudowords. Given the magnitude of this result, the hypothesis should be raised that RAN training can have a very large impact on learning to read in an adult population. A recent study, conducted with children, begins to bring evidence to support this hypothesis. When assessing the effect of interventions based on PA and RAN training in second-year children, Stappen and Reybroeck⁽³⁰⁾ showed that these skills are independent, that is, training in a specific skill does not impact improvement of the skill that was not trained. In addition, the PA intervention contributed to decrease in the proportion of phonological errors during writing, while the RAN intervention contributed to reading speed, and

these effects were maintained for six months⁽³⁰⁾. However, to date, no study has been conducted investigating the effects of RAN interventions on functional illiterate adults.

It is important to note that, although there is a great variation in the age range of the study's participants, this measure does not seem to influence the results in reading. In fact, the regression analysis, with age as an independent variable, could not increase the estimation rate of the participants' performance on the WPRCT. Another reason to maintain a group with such a heterogeneous age group is for it to be a representative sample of students enrolled in the youth and adult education modality in Brazil⁽¹⁴⁾.

The results produced by the present study can contribute to understanding the cognitive processes underlying acquisition of reading and writing by adults and, consequently, to shed light on new forms of intervention for teaching reading in adult literacy programs. As seen, intervening in rapid automatized naming may be a new possibility to prevent and remedy adult reading difficulties, and may also be a new topic for future investigations.

Among the study's limitations, the following stand out: reduced sample size and great age variation of participants; scarcity of intelligence instruments with standards for partially literate adults; heterogeneity depending on the level of reading, as some participants were only able to read isolated words, while others read small texts; absence of standardized reading assessment instruments that make it possible to more accurately identify the level of functional illiteracy.

CONCLUSION

The present study concludes that functionally illiterate adults had difficulties in phonological awareness, showing poor performance in tasks involving phoneme analysis and manipulation. In rapid automatized naming, they found it easier to name alphanumeric items. Regarding reading, there were difficulties in phonological processing, with errors due to phonological exchange. The correlation analyses indicated that rapid automatized naming correlates more with group reading performance than with phonological awareness. Finally, the regression analysis indicated that performance in rapid automatized naming alone can explain more than half of the participants' reading results. In general, it can be said that functionally illiterate adults present impaired skills considering the capabilities assessed. It is also possible to state that rapid automatized naming has a greater influence on the reading performance of this population.

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REFERENCES

1. UNESCO: United Nations Educational, Scientific and Cultural Organization. Literacy rates continue to rise from one generation to the next. Paris: Unesco; 2017
2. IBGE: Instituto Brasileiro de Geografia e Estatística. Pesquisa nacional por amostra de domicílios contínua: educação 2018. Rio de Janeiro: IBGE; 2019.
3. Ação Educativa, Instituto Paulo Montenegro. Indicador de alfabetismo funcional 2018: resultados preliminares. Instituto Paulo Montenegro e Ação Educativa; 2018.
4. Wagner RK, Torgesen JK. The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychol Bull.* 1987;101(2):192-212. <http://dx.doi.org/10.1037/0033-2909.101.2.192>.
5. 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.
6. Vander Stappen C, Reybroeck MV. Phonological awareness and rapid automatized naming are independent phonological competencies with specific impacts on word reading and spelling: an intervention study. *Front Psychol.* 2018;9:320. <http://dx.doi.org/10.3389/fpsyg.2018.00320>. PMID:29593618.
7. Landgraf S, Beyer R, Hild I, Schneider N, Horn E, Schaadt G, et al. Impact of phonological processing skills on written language acquisition in illiterate adults. *Dev Cogn Neurosci.* 2012;2(Supl 1):S129-38. <http://dx.doi.org/10.1016/j.dcn.2011.11.006>. PMID:22682902.
8. Dehaene S, Cohen L, Morais J, Kolinsky R. Illiterate to literate: behavioural and cerebral changes induced by reading acquisition. *Nat Rev Neurosci.* 2015;16(4):234-44. <http://dx.doi.org/10.1038/nrn3924>. PMID:25783611.
9. Boltzmann M, Mohammadi B, Samii A, Münte TF, Rüsseler J. Structural changes in functionally illiterate adults after intensive training. *Neuroscience.* 2017;344:229-42. <http://dx.doi.org/10.1016/j.neuroscience.2016.12.049>. PMID:28069530.
10. Braga LW, Amemiya E, Tauli A, Suguieda D, Lacerda C, Klein E, et al. Tracking adult literacy acquisition with functional MRI: a single-case study. *Mind Brain Educ.* 2017;11(3):121-32. <http://dx.doi.org/10.1111/mbe.12143>.
11. Araújo S, Fernandes T, Huettig F. Learning to read facilitates the retrieval of phonological representations in rapid automatized naming: evidence from unschooled illiterate, ex-illiterate, and schooled literate adults. *Dev Sci.* 2019;22(4):e12783. <http://dx.doi.org/10.1111/desc.12783>. PMID:30516315.
12. Bottino AG, Correa J. A compreensão leitora de jovens e adultos tardiamente escolarizados. *Psicol Reflex Crit.* 2013;26(2):405-13. <http://dx.doi.org/10.1590/S0102-79722013000200021>.
13. Corrêa MF, Cardoso-Martins C. O papel da consciência fonológica e da nomeação seriada rápida na alfabetização de adultos. *Psicol Reflex Crit.* 2012;25(4):802-8. <http://dx.doi.org/10.1590/S0102-79722012000400020>.
14. Todos Pela Educação. Anuário brasileiro da educação básica. São Paulo: Moderna; 2019.
15. Seabra AG, Capovilla FC. Teste de competência de leitura de palavras e pseudopalavras. São Paulo: Memnon; 2010.
16. Trentini CM, Yates DB, Heck VS. Escala de Inteligência Wechsler Abreviada (WASI): manual profissional. São Paulo: Casa do Psicólogo; 2014.
17. Lukasova K. Alterações fonológicas e motoras na dislexia do desenvolvimento [dissertação]. São Paulo: Universidade Presbiteriana Mackenzie; 2006.
18. Scarton CE, Aluísio SM. Análise da inteligibilidade de textos via ferramentas de Processamento de Língua Natural: adaptando as métricas do Coh-Metrix para o Português. *Linguística.* 2010;2(1):45-61.
19. Seabra AG, Capovilla FC. Prova de consciência fonológica por produção oral In: Seabra AG, Dias NM, editores. Avaliação neuropsicológica cognitiva: linguagem oral. São Paulo: Memnon; 2012.
20. Silva PB, Mecca TP, Macedo EC. Teste de Nomeação Automática – TENA: manual. São Paulo: Hogrefe; 2018.
21. Kolinsky R. How learning to read influences language and cognition. In: Pollatsek A, Treiman R. *The Oxford handbook of reading.* New York: Oxford University Press; 2015.
22. Yassuda MS, Diniz BSO, Flaks MK, Viola LF, Pereira FS, Nunes PV, et al. Neuropsychological profile of Brazilian older adults with heterogeneous

- educational backgrounds. *Arch Clin Neuropsychol*. 2009;24(1):71-9. <http://dx.doi.org/10.1093/arclin/acp009>. PMID:19041220.
23. Landgraf S, Beyer R, Pannekamp A, Schaadt G, Koch D, Foth M, et al. Dissociating improvement of attention and intelligence during written language acquisition in adults. *Int J Intell Sci*. 2011;01(02):17-24. <http://dx.doi.org/10.4236/ijis.2011.12003>.
24. Vágvölgyi R, Rohland LM, Sahlender M, Dresler T, Schrader J, Nuerk HC. Diversity of functional illiterate cases: results from a multiple-single case study. *Z Erziehungswiss*. 2019;22(1):123-51. <http://dx.doi.org/10.1007/s11618-018-00863-z>.
25. Dias NM, Minervino CASM, Reppold CT, Macedo EC, Seabra AG. Avaliação das estratégias de leitura em leitores típicos e disléxicos: abordagem neuropsicológica. *Psicol Teor Prat*. 2015;17(2):171-84. <http://dx.doi.org/10.15348/1980-6906/psicologia.v17n2p171-184>.
26. Toledo Piza CM, Macedo EC, Miranda MC, Bueno OFA. Contrasting group analysis of Brazilian students with dyslexia and good readers using the computerized reading and writing assessment battery “BALE”. *Front Psychol*. 2014;5:837. PMID:25132829.
27. Huettig F, Lachmann T, Reis A, Petersson KM. Distinguishing cause from effect: many deficits associated with developmental dyslexia may be a consequence of reduced and suboptimal reading experience. *Lang Cogn Neurosci*. 2018;33(3):333-50. <http://dx.doi.org/10.1080/23273798.2017.1348528>.
28. Huettig F, Kolinsky R, Lachmann T. The culturally coopted brain: how literacy affects the human mind. *Lang Cogn Neurosci*. 2018;33(3):275-7. <http://dx.doi.org/10.1080/23273798.2018.1425803>.
29. Corrêa MF. Como os adultos aprendem a ler? Evidências de um estudo com adultos pouco alfabetizados e crianças com a mesma habilidade de leitura [dissertação]. Belo Horizonte: Universidade Federal de Minas Gerais; 2009.
30. Vander Stappen C, Reybroeck MV. Phonological awareness and rapid automatized naming are independent phonological competencies with specific impacts on word reading and spelling: an intervention study. *Front Psychol*. 2018;9:320. <http://dx.doi.org/10.3389/fpsyg.2018.00320>. PMID:29593618.

Authors' contributions

MSM was responsible for the study design, data collection, statistical analysis and writing of the manuscript; ECM was responsible for the study design, statistical analysis, writing of the manuscript and supervision of the first author.