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Keywords

Memory
Learning
Speech, Language and Hearing
Sciences
Child
Underachievement

Descritores

Memória
Aprendizagem
Fonoaudiologia
Criança
Baixo Rendimento Escolar

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Received: July 01, 2016

Accepted: February 02, 2017

Relation between arithmetic performance and phonological working memory in children

Relação entre o desempenho em aritmética e a memória de trabalho fonológica em crianças

ABSTRACT

Purpose: To compare the results of Loop Phonological Working Memory (LPWM) in children without global learning alterations, with lower and average/higher arithmetic performance. **Methods:** The study was conducted with 30 children, between the ages of seven and nine years old, who attended the second or third grade of elementary school in the public network. Exclusion criteria were children with suggestive signs of hearing loss, neurological disorders, poor performance in the reading comprehension test or in speech therapy. The children included in the study were submitted to the subtest of arithmetic of Academic Achievement Test for division into two groups (G1 and G2). The G1 was composed of children with low performance in arithmetic and G2 for children with average/higher performance in arithmetic. All children were submitted to PWM assessment through the repetition of pseudowords test. Statistical analysis was performed using the Mann-Whitney test and a p-value <0.05 was considered significant. **Results:** The study included 20 girls and 10 boys, mean age 8.7 years. The G1 was composed of 17 children and G2 of 13 children. There was a statistically significant difference between the groups studied for the repetition of pseudowords with three and four syllables. **Conclusion:** The results of this study provide support for the hypothesis that changes in phonological working memory are related to difficulties in arithmetic tests.

RESUMO

Objetivo: Comparar os resultados da Memória de Trabalho - Alça Fonológica (MTAF) em crianças com dificuldades específicas em aritmética. **Método:** O estudo foi realizado com 30 crianças, com idade entre sete e nove anos que frequentavam a segunda ou terceira série do Ensino Fundamental da rede pública de ensino. Foram excluídas da pesquisa as crianças com sinais sugestivos de perda auditiva, alterações neurológicas, baixo desempenho na prova de compreensão leitora ou em acompanhamento fonoaudiológico. As crianças incluídas na pesquisa foram submetidas ao subteste de aritmética do Teste de Desempenho Escolar para divisão em dois grupos (G1 e G2). O G1 foi composto por crianças com baixo desempenho em aritmética e o G2, por crianças com desempenho médio/superior em aritmética. Todas as crianças foram submetidas à avaliação da MTAF por meio da prova de repetição de palavras sem significado. Para análise estatística, foi utilizado o teste de *Mann-Whitney*, considerados significativos os valores de p-valor <0,05. **Resultados:** Participaram do estudo 20 meninas e 10 meninos, com idade média de 8,7 anos. O G1 foi composto por 17 crianças e o G2, por 13 crianças. Houve diferença estatisticamente significativa entre os grupos estudados para a repetição de palavras sem significado com três e quatro sílabas, com pior desempenho para o G1. **Conclusão:** Os resultados deste estudo fornecem suporte para a hipótese de que a alteração na MTAF está relacionada com dificuldades em aritméticas.

Study carried out at Faculdade de Medicina de Ribeirão Preto – FMRP, Universidade de São Paulo – USP - Ribeirão Preto (SP), Brazil.

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Financial support: nothing to declare.

Conflict of interests: nothing to declare.

INTRODUCTION

Working memory is involved in the temporary storage necessary for the mental manipulation of information, being indispensable in different complex cognitive functions. Amongst the subcomponents that make up this memory is the Phonological Loop Working Memory (PLWM) which is constituted by the phonological buffer and articulatory loop^(1,2).

A way to evaluate the PLWM is by using the repetition of non-words or pseudo-words, given that this strategy eliminates the influence of lexical, semantic or syntactic clues⁽¹⁾.

In recent decades, studies involving PLWM have investigated its influence on performance in reading⁽³⁾ and arithmetic⁽⁴⁾. However, there is no consensus in the literature regarding the relationship between PLWM and arithmetic⁽³⁻⁶⁾.

In this manner, studies that assess performance in arithmetic, without other alterations to learning, are necessary. Therefore, the objective of this study was to compare results in PLWM tasks, in children with specific difficulties in arithmetic.

METHODS

The present study was considered and approved by the Ethics Committee under the review n° 9503/2007. All the participants and their dependents were informed regarding the study and expressed their consent by way of signature on the Free and informed Consent.

The study was conducted with 30 children, of both genders, with ages between seven and nine years, who attended the third and fourth year of Primary School in the municipal public network. The selection of the school was done in a random manner by the Secretary of Education of the municipality and the children were selected by drawing lots in the target grades.

All children with signs of hearing loss, neurological alterations, difficulties with reading/writing, low performance on the reading comprehension test or in speech therapy treatment were excluded from the study.

The Tonal Threshold Audiometry test was conducted using Beta 6000 model equipment, Beta Medical brand. For the exclusion of the children with reading/writing difficulties, the teacher was asked to assess the performance of each student in reading and writing tasks as well as by utilizing the Reading of Sentences Competency test or TeCoLeSi⁽⁷⁾ to determine reading comprehension. We opted for excluding from the research, children with difficulties in reading and writing tasks to avoid erroneous conclusions. Therefore, only children with specific difficulties with arithmetic participated.

The children included in the research were submitted to the *Teste de Desempenho Escolar* (TDE)⁽⁸⁾ subtest, according to the indications of the test authors. Following this, the children were divided into two groups, using the standards for normality suggested by the test. One group was made up of children with a performance below that expected for their age and schooling (G1) and the other group, was made up of children who obtained an average performance or above expectation (G2).

Following this, all the children were submitted to MTF evaluation using the repetition of words without meaning test⁽⁹⁾.

The data was statistically processed using the SPSS 16.0[®] software. The Mann-Whitney test was used and p-values of <0.05 were considered significant.

RESULTS

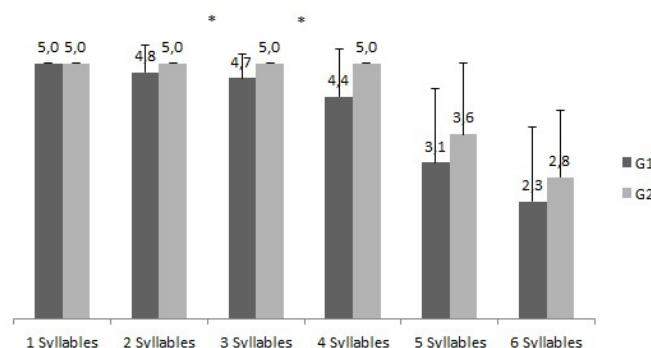
20 female and 10 male children participated in the study, with 14 being from the third and 16 from the fourth year of Primary Schooling. The average age was 8.7 years old.

The G1 was made up of 17 children with a poor performance on the TDE arithmetic test and the G2 was made up of 13 children with an average or higher performance on the same test.

Graph 1 illustrates the results on the PLWM test for both study groups.

Table 1 presents the number of children, in each group, who achieved the maximum score for each number of syllables.

Graph 1. Comparison between the results for Phonological Working Memory in children with poor performance and average/higher performance in arithmetic



Legend: *expressed by p-value <0.05 according to the Mann-Whitney test. G1- children with poor performance and G2- children with average/higher performance in the TDE arithmetic subtest

Table 1. Number of children who achieved the maximum score on the test for repetition of words without meaning by group studied

Group	1 Syllable	2 Syllable	3 Syllable	4 Syllable	5 Syllable	6 Syllable
G1	17(100%)	15(88.2%)	12(70.6%)	10(58.8%)	3(17.6%)	0(0%)
G2	13(100%)	13(100%)	13(100%)	13(100%)	3(23.7%)	2(15.4%)

Legend: Group: G1- made up of children with poor performance in arithmetic and G2 – made up of children with average/higher performance in arithmetic

DISCUSSION

The present study showed that, to the extent that the number of syllables in the words without meaning increased, there was a reduction in the number of correct responses from the children during the PLWM test, in both groups. This finding is in agreement with various studies^(3,9,10,11), confirming the influence of the length of words on performance in the MTF.

In the literature, the use of two main tests for the evaluation of PLWM was found, the repetition of non-words (or words without meaning) and the repetition of numbers both forwards and backwards. However, in this study, we opted for using only the test of repetition of words without meaning due to this test not providing any lexical clues, which facilitate memorization.

In this study, the comparison between the performance in the PLWM of children with an inferior performance (G1) with that of the children with average/higher performance in arithmetic (G2) was carried out. A significant difference can be observed between the groups in the execution of the test, with three and four syllables.

Though the effect of length in both groups is clear, we can observe, in Table 1, that this effect appears in G2 with words with a greater number of syllables (4 syllables or more), but appearing in shorter words in G1.

Some studies point toward a possible role for phonological memory in the realization of mathematical tasks⁽⁵⁾, more specifically due to the recruitment of executive functions^(12,13). Other studies in their turn, showed no relationship between performance on the arithmetic tests and the MTF, however, in these studies, children with overall learning difficulties were not excluded⁽⁶⁾.

Corso and Dorneles⁽¹³⁾, in their revision article, affirmed, based on the literature reviewed, that working memory would sustain the development of the diverse types of learning, including mathematics and that an alteration in one of its subcomponents is capable of leading to specific mathematical difficulties, as was seen in the present study.

The relationship between PLWM and performance in arithmetic can be explained by the fact that, for the realization of the mathematical operations, one should maintain in the memory the task to be executed while you mentally solve the problem. Further, working memory is related to other cognitive processes, which can also interfere with mathematical performance, such as processing speed⁽¹³⁾ and the recuperation of arithmetical facts contained in long-term memory^(13,14).

Therefore, this study showed that a poor performance in arithmetic, independent of other more global academic alterations (reading/writing) can be associated with an alteration in PLWM, which extends the discussion regarding the subject and shows the scientific community the importance of this evaluation even in children who present good academic performance and adequate reading comprehension.

CONCLUSION

The results of this study provided support for the hypothesis that there is a relationship between Phonological Loop Working Memory and performance in arithmetic tests, given that, in cases of specific alterations in arithmetic, it is probable that the child will also present alterations in the tasks evaluated for PLWM.

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Author contributions

KS undertook the bibliographic review, analysis of the results and writing of the manuscript; PAZ carried out the statistical analysis, interpretation and discussion of the results; RBGG did the analysis and interpretation of the results; VTRB realized the data collection and bibliographical revision; RCSK carried out data collection; DRD carried out the analysis and interpretation of results; MTHF carried out the conceptualization, orientation and general supervision of the study.