# DIFFERENCE BETWEEN VERBAL AND VISUAL SPAN IN GENDERS: PILOT STUDY

## *Diferença entre span verbal e visual nos gêneros: estudo piloto*

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**ABSTRACT**

**Purpose:** to evaluate the working memory analyzing the retention ability of auditory stimuli (verbal span) and visual stimuli (visual span), and to establish its relation to gender (male and female). **Method:** 20 subjects – 10 female children and 10 male children – from six and five months to seven years old took part in this study. All subjects were submitted to evaluation tests for both verbal and visual spans in direct and inverse orders. **Results:** there was a significant variance between genders only in the test involving disyllabic words with phonology similar to and semantics different from verbal span. Female children showed a better performance in relation to the other gender, as well as a better retention ability as for two-syllable words with different phonology and semantics. In the tests for visual span (direct and inverse orders) the male children showed a better performance, but the differences were not significant. In relation to age, there was no any difference in the retention of stimuli. **Conclusion:** in this study, female children showed a trend to achieve a better performance in the verbal span, and the male children showed a trend to achieve a better performance in the visual span. However, this study is limited, due to the reduced number of subjects in the sample.

**KEYWORDS:** Memory, Short-Term; Employee Performance Appraisal; Executive Function

## INTRODUCTION

After 40 years of study on memory, it is known that this skill is more complex than the idea they had in the sixties. The memory processing is not sequential but parallel, starting with working memory, short-term and subsequently culminating in long-term memory[1]. The current model of memory began with the study[2] which found that the short-term memory does not store information for a short period of time, leaving this function to the working memory, currently defined as a complex system of temporary storage and manipulation of information during language processing, learning, and logical reasoning[3].

Studies show that working memory has a decisive role in the development of oral language and communication for children, allows formal and informal learning, acquire new knowledge and information integration. The language and memory systems are developed at the same time, interact between themselves and are dependent[4].

The working memory[3, 5,6] is divided into three main sub-systems, managed by the central executive, which are: phonological loop, visuo-spatial layout and the episodic buffer. "The central executive is involved with the development of strategies which provide increased storage capacity of the sub-systems subordinated to it" [6]. The central executive is related to more complex cognitive activities, being able to regularize, process, store and control the flow of information to the phonological loop and the visuo-spatial sketchpad[7]. The central executive is also responsible for directing attention to relevant information, coordinating cognitive processes when more than one task must be performed at the same time and can be assessed with tests such as digit span[8].

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The phonological loop is responsible for the processing of linguistic materials, has two subcomponents: the phonological storer (file which holds oral or written phonological material, but deteriorates with time) and reverberation subvocal (makes the feedback of the elements which are lost in time through subvocalization). The functioning of the phonological loop is extremely important, for besides keeping information for a longer period also facilitates the consolidation of material in short and long term memory. The interaction between its subcomponents is the basis for the maintenance and manipulation of information within the phonological loop. The second sub-system is the visual-spatial scheme, which involves especially the inferior parietal lobe and right dorsal visual cortex. The visuo-spatial scheme is responsible for the temporary storage of visual and spatial information and assisting in activities such as: recognition of the way and the face of a known person[3].

The episodic buffer is the third subsystem[9] that compose the model of working memory, and a system that retrieves information from long-term memory, make it aware and allows to relate to phonological and visual space information, from the external environment.

To assess working memory span tests are performed to determine the retention capacity. According to Bjorku apud[10], the *Span* can be defined as the ability to store and repeat the list in the forward or reverse, seconds after the presentation. About the storage, long words lead to smaller span than short words, or words that take a long time to exhibit articulated smaller span than short words with long hinge. This result is called the word length effects. The inverse span requires more attention, because the last items are more dependent on phonological aspects and the first more dependent on semantic aspects, and this is reversed during the recording of the components of the list to be remembered[10]. In the same study[10], it was shown that working memory is influenced by semantic and phonological factors and the immediate recall of words with phonological similarity is impaired. This phenomenon is known as phonological similarity effect, it occurs because the similarity noise creates phonological confusion (Andrade, 2002)[10].

The larger the child's vocabulary, sublexical knowledge and morphology of the language is, the better the performance in verbal span[11]. A study[12] that reviewed publications since the 80s has concluded that there is an increased ability to retain phonological child development, which facilitates the acquisition of new vocabulary and extensive sentence comprehension or more syntactic complexity. Still, according to some studies[12, 13], working memory also contributes to the acquisition of metalinguistic skills, judgment grammatical sequence and phonological awareness.

To Harness, Jacot, Scherf, White, Warnick[14] female subjects perform better in visual working memory, but to Alloway, Gathercole, Pickering[15] there is no difference in performance in tests of working memory, auditory and visual between the genders.

Knowing that working memory plays a fundamental role in cognitive activities, this study aims to investigate the ability of the verbal span and visual work of students who are in the process of literacy and observe the differences in performance between female and male children.

## METHOD

### Participants

Twenty students enrolled in the 1st year of Disnei Francisco Scornaienchi elementary state school which serves students from the 1st year of primary school to 3rd year of high school, located in the southern region of Campinas participated in this study.

Two groups consisted of 10 male children (GM) and 10 females (GF), aged from 6 years and 5 months old to 7 years old. Regarding age, there were no differences between groups ($\chi^2$ = 0.00, df = 7, p = 1,00). The average age of the total sample was 80.2 months ($\pm$ 2.44) which corresponds to 6 years and 7 months. The average ages of the groups GM and GF were 80.2 ($\pm$ 2.44), so that there were no significant differences (p = 1,00).

Inclusion criteria for participation in this study were: signing the Informed Consent Form (ICF), being in the first year of elementary school, presenting normal psychomotor development, presenting typical speech development, having attended two years of preschool , not presenting suspicion of hearing and visual impairment, not complaining of speech-language disorders such as learning disabilities, delayed speech, phonetic and/or phonological diversion, mouth breathing, not being or having a history of speech therapy, not using neurological and psychiatric medication, not attending psychological care, tutoring or educational support. Exclusion criteria were: presenting altered neuropsychomotor development and atypical development of speech; having attended less than 2 years of preschool; presenting suspected auditory and visual deficits; having complaints of speech-language disorders such as learning disabilities, language delay, phonetic and/or phonological diversion and oral breathing, being in a or having a history of speech therapy; making use of

neurological and psychiatric medication, attending educational psychology service, tutoring or educational support.

It was used a questionnaire developed by the authors, which was filled by the students' parents for selection of whom could participate in the study. In it, there were the following questions: Has the child attended kindergarten for two years to say the least? Does the child present the framework of neurological disease? Does the child present sensory deficit? Does the child present display motor change? Did the child show developmental delay? Does the child use neuropsychiatric medication? There was collaboration of the students' teachers in order to identify those who were excluded because they showed signs of learning disabilities, speech disorders, having performed speech or psycho therapy and tutoring.

**Instruments**

Verbal span proof is composed of lists of two-syllable words with different phonology and semantics and words with similar phonology and different semantics. The proof starts with a word and the child must repeat it. Gradually it increases up to seven words, and in each series there are different words than the ones presented earlier. In the event of errors from two sequences the test was terminated. It was considered the errors of omission or addition of words and changing the order of the repetition. A record was done of the order and form of repetition.

In proof of Visual Span rectangular colored cards were used (6cm x 10cm) in blue, yellow, black, white, red, green and pink. In this test, the sequence has been initiated by a color, and in each new sequence a new color was added to the last sequence of seven colors, but the order of colors did not repeat. In the visual span test in reverse order, students should place the cards in the reverse order that it was presented. The test was terminated when the child missed two sequences. It was considered the error by omission or addition of cards and changing of the order of the repetition. A record was done of the order and form of repetition.

**Procedures**

The subjects underwent the following subtests of verbal and visual span in the forward and reverse order in the evaluation protocol of working memory for visual and audio material. Each student was tested individually during one session of about 25 minutes and during the test there was no change in the order of application.

To easy the reader's understanding, the names of each applied subtest were transformed into acronyms as in the figure below:

| | |
|---|---|
| A1 | Verbal span - Dissyllable words with different phonology and semantics |
| B1 | Verbal span - Dissyllable words with similar phonology and different semantics |
| A2 | Visual span - Direct order |
| B2 | Visual span - Reverse order |

**Figure 1 – Acronyms of the subtests for verbal and visual span**

The study was conducted after the approval of the Ethics Committee in Research (no. 751/2010) of the College of Medical Sciences, UNICAMP.

Data were statistically analyzed using Student's t test and Pearson SPSS (*Statistical Package for the Social Sciences*) version 16.0. It was adopted a significance level of 5%, for the application of statistical tests, being considered a statistically significant difference when the p value is higher than or equal to 0.050 ($p>0.05$).

## RESULTS

### Descriptive statistics of the tests

Table 1 shows the highest and lowest number of correct answers, the average and standard deviation for each test. In A1, the worst performance was two correct answers and the best was four correct answers, with average of 3.85 and standard deviation of 0.49. In test B1, the worst and the best performance test are equal to A1, but the average is 3.10 and the standard deviation is equal to 0.55. Test A2, the lowest performance was 3 correct answers and the biggest number of correct answers was 5, where the average was 3.70 correct answers and standard deviation equal to 0.66. Test B2, the worst performance was the one correct answer and the best 4 correct answers, with an average of 2:55 and a standard deviation of 0.94.

**Table 1 – Descriptive statistics of tests**

| | Minimun | Maximun | A | SD |
|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic |
| A1 | 2,00 | 4,00 | 3,85 | ,49 |
| B1 | 2,00 | 4,00 | 3,10 | ,55 |
| A2 | 3,00 | 5,00 | 3,70 | ,66 |
| B2 | 1,00 | 4,00 | 2,55 | ,94 |

Legend: A = Average, SD = Standard Deviation

### Comparação das médias dos testes entre os grupos

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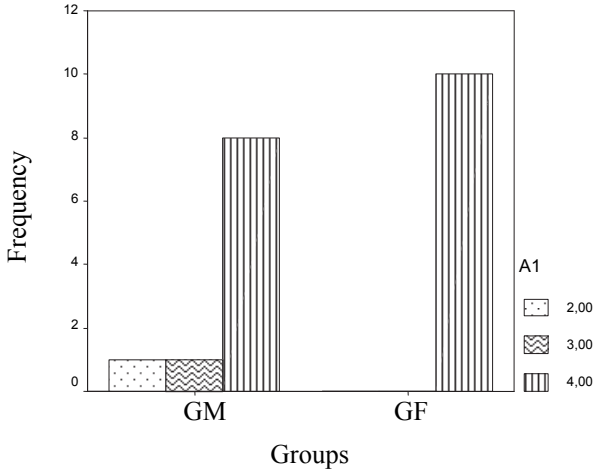


**Figure 2 – Distribution of frequency of the test scores for verbal span (A1)**

Figure 2 shows the performance of the memory capacity of two-syllable words with different semantics and phonology in direct order in the proof of Verbal Span. In GF group all subjects stored up to 4 words as for the GM group, 8 subjects stored 4 words, a subject stored three words and the other only two words.

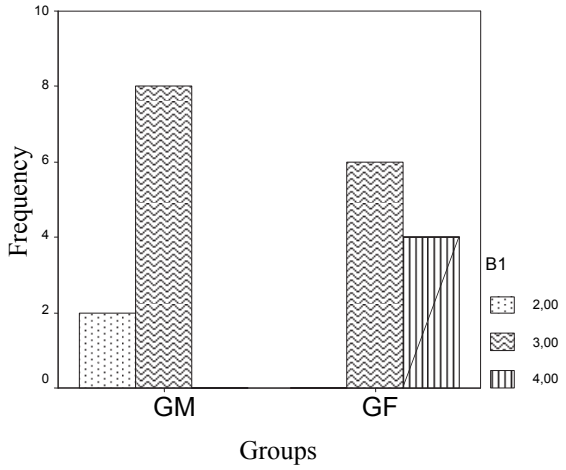


**Figure 3 – Distribution of frequency of the test scores for verbal span (B1)**

Figure 3 shows the performance of GM and GF groups in verbal Span of dissyllable words with similar phonology and different semantics. It was observed that in the GM group, 8 subjects had three corrects answers and two subjects 2 corrects answers. In the GF group 6 subjects had 3 corrects answers and 4 subjects had 4 corrects answers.

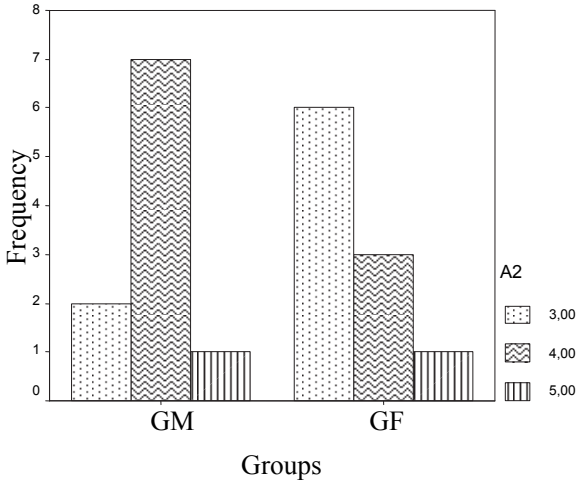


**Figure 4 – Distribution of frequency of the test scores for visual span (A2)**

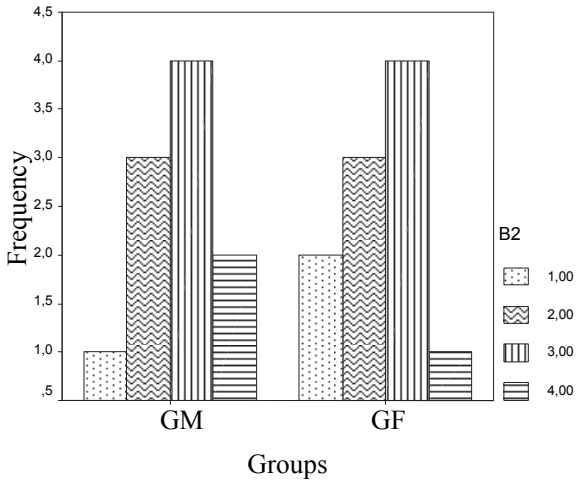


**Figure 5 – Distribution of frequency of the test scores for visual span (B2)**

It is observed that in the GM group that two children had 3 correct answers, seven children had 4 correct answers and one child had 5 correct answers. In the GF group 6 children had 3 correct answers, 3 children had 4 correct answers and 1 child had 5 correct answers.

In the GM group, one child got one correct answer, three kids had 2 correct answers, four kids had 3 correct answers and two children had 4 correct answers. The GF group, two children had one correct answer, three had 2 correct answers, 4 children had 3 correct answers and one had 4 correct answers.

**Table 2 – Comparison of different tests in relation to gender**

| GM – Male | | | GF - Female | | |
|---|---|---|---|---|---|
| ***Tests*** | ***A*** | ***p*** | ***Tests*** | ***A*** | ***p[a]*** |
| A1 | 3,70 | 0,00 | A1 | 4,00 | 0,00 |
| A2 | 2,80 | | A2 | 3,40 | |
| A2 | 3,90 | 0,00 | A2 | 3,50 | 0,01* |
| B2 | 2,70 | | B2 | 2,40 | |
| A1 | 3,70 | 0,48 | A1 | 4,00 | 0,04 |
| A2 | 3,90 | | A2 | 3,50 | |
| B1 | 2,80 | 0,76 | B1 | 3,40 | 0,01 |
| B2 | 2,70 | | B2 | 2,40 | |

Legend: [a] – Student's test t; A = Average, SD = Standard Deviation * statistically significant difference

It was performed the Student's t test to compare the averages of the tests between groups. The results indicate that only the verbal Span Test with dissyllable words with similar phonology and different semantics showed significant differences (p =0.01).

**Table 3 – Descriptive statistics and inferential tests between groups**

| | Groups | A | SD | *p* |
|---|---|---|---|---|
| A1 | GM | 3,70 | ,67 | ,18 |
| | GF | 4,00 | ,00 | |
| B1 | GM | 2,80 | ,42 | 0,01* |
| | GF | 3,40 | ,52 | |
| A2 | GM | 3,90 | ,57 | ,18 |
| | GF | 3,50 | ,71 | |
| B2 | GM | 2,70 | ,95 | ,49 |
| | GF | 2,40 | ,97 | |

Legend: A = Average, SD = Standard Deviation; p = p value * statistically significant difference

This table describes the average and the standard deviation of the performance of the two groups on A1 and B1 verbal span and A2 and B2 visual span. Only in the proof of verbal Span words with phonological similarity and semantic difference statistically significant difference was found between groups.

The Pearson correlation analysis indicated that there was no correlation between age and the results. There was a positive correlation between tests of verbal span, A1 and B1 ($r = 0.45$, $p = 0.05$) for the GF group composed of female children and between visual span tests A2 and B2 ($r = 0.53$, $p = 0.02$) for the GM group composed of male children.

## DISCUSSION

Initially, it is necessary to point out that in the two studied groups there was no difference in the performance between the ages. This is because they are only 7 months apart between the older subject and the younger. Gindri, Keske-Soares and Mota[16] compared the performance of working memory of students in kindergarten and first grade of elementary school and proved the existence of a direct relationship of chronological age with the acquisition of reading and writing, noting that students of first grade of elementary school, had performed better than students from pre-school, since they were already literate and had more time to interact with the metalinguistic skills. Another study[17] assessed visual-spatial working memory in a group of students aged from 7 to 12 years old, and it proved a better performance from the students with 11 and 12 years in relation to the others.

Andrade[10] conducted a survey that evaluated children from 7 to 10 years and 11 months old with ADHD and compared with the control group of children who did not have any information about developmental delay, hearing impairment, visual, neurological and school failure. The average of the control group in the test A1 (repetition of two-syllable words with different phonology and semantics) was 3.95 correct answers and in A2 test (two-syllable words with similar phonology and different semantics) was 3.31 correct answers confronting the averages shown in Table 2, the average in A1 was 3.8 correct answers and in A2 was 3.10 hits. It was observed that the averages found in the earlier survey[10] are superior, although similar. However, the ages are mixed between the two studies, as well as the level of education, since the former analyzed students who attended all years of the elementary school[10] and the present study was conducted with first year students.

These findings corroborate the results of other studies[15, 16], which states that the storage capacity of the phonological loop is relatively constant during development, although the school learning increases system efficiency. When researching the phonological loop in adults and elderly[18], it was found that aging makes this component less efficient, it is proven with a poor performance in immediate recall. As for education, it is known that individuals with higher education have a more efficient use of articulation component and consequently proved that this group has performed better in immediate memory[18].

As shown in Figure 2, females performed better in A1 (repetition of two-syllable words with different semantics and phonology) than males. Making another analysis of the same test, Table 4 shows that the average for GF is superior to GM, although there was no statistically significant difference.

Figure 3 shows the superior performance of GF in B1 (two-syllable words with different semantics and phonology). It is important to consider that in this test, there was significant variance between groups. Table 4 shows this difference by comparing the averages of the two groups. In this test, GF has averaged just 3.4 correct answers while GM

2.8 correct answers. Thus, the female subjects performed better on verbal span, i.e., retained more verbal stimulus than boys. This data does not corroborate with the study[19] which found that boys had better performances in five-syllable repetition of pseudo words. Although the tests are different, they evaluate the storage capacity of phonological material in the working memory. However, studies[15, 20] that evaluated the development of working memory throughout the early grades of elementary school, depending on gender, age and school year showed that the gender variable had no significant difference.

In the analysis of Figures 4 and 5 it can be seen better performance of males in the visual span, even though no significant variation was found. This finding does not corroborate the study of Harness, Jacot, White, Warnik[14] where there was better performance of female subjects in tasks of visual working memory.

With this study it is possible to prove the effect of extension and limitation of the stimulation of working memory, since the greater the time to enunciate the sequence (verbal span) and/or the number of cards to sort (visual span), the more errors occur for both the male subjects, as for the female. These findings corroborate the study[18] that demonstrated the greater the time to enunciate the sequence, the more errors occurred in both genders. Discussing findings from the 80s on the assessment of working memory in children, it was found that all ages suffer from the effect of the extension of words[12].

Observing Table 2 it is possible to observe a decrease in the number of correct answers for boys and girls of the A1 (two-syllable words with different semantics and phonology) for the B1 test (two-syllable words with different semantics and similar phonology). These results agree with those studies which found a decreasing pattern in the number of correct repetitions in performance due to phonological similarity effect, the phonological loop, i.e., words with similar final sounds hinder the meaning, and thus are more difficult to be remembered[10].

Concerning the visual working memory, visual proof span did not involve in speech, there was no involvement with the phonological loop, since the children did not even need to know the names of the colors; they just needed to order in a direct or reverse form the colored cards. The results in both groups are in the best performance of 2A (direct order visual span) with an average of 3.7 correct answers than 2B (reverse visual span) with an average of 2.55 correct answers. This result occurs because the memory in reverse order requires more attention to store and is not a usual task, thus requiring greater demand for cognitive flexibility. In the study[10] which applied this same test in children with ADHD and in the control group and the results corroborate with the findings in this research. Children with ADHD had an average of 2.43 correct answers in 2A and 2B of 2.10 correct answers. The control group achieved a performance of 3.54 in direct order and 3.11 in reverse order.

## CONCLUSION

In this research it can be seen a pattern towards a better performance of girls in tests of verbal span, although there is a statistically significant difference between genders only in the repetition of words with similar phonology and different semantics. In the visual span in the direct and reverse order, the boys tended to perform better in both tests.

GF and GM groups performed better on the test of direct visual span than the reverse. Concerning verbal span, both groups were better at repeating two-syllable words with different phonology and semantics than in two-syllable words with different semantics and similar phonology. However, this study is limited due to the small number of subjects in the sample, but the results meet the what was proposed as it is a pilot study.

In this study there was no difference in performance in the studied group in relation to age and it is noteworthy that there are few studies on the relationship between working memory and gender.

The findings of this study can help professionals involved with student learning in the early years because knowing the actual load span that the system can hold, they are able to propose more appropriate and which stimulate in a more effective way the necessary skills and facilitators of the literacy process and allows the knowledge of the difference in performance between the genders.

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**RESUMO**

**Objetivo:** avaliar a memória de trabalho analisando a capacidade de retenção de estímulos auditivos (span verbal) e visuais (span visual) e estabelecer a relação com o gênero (masculino e feminino). **Método:** participaram deste estudo 20 crianças entre seis anos e cinco meses e sete anos, sendo 10 sujeitos do sexo masculino e 10 sujeitos do sexo feminino. Todos os sujeitos foram submetidos às provas de avaliação do span verbal e visual em ordem direta e inversa. **Resultados:** apenas na prova de palavras dissílabas com fonologia semelhante e semântica diferente do span verbal, houve variância significante entre os gêneros. As crianças do sexo feminino apresentaram melhor desempenho em relação ao outro gênero, bem como maior capacidade de retenção de palavras dissílabas com fonologia e semântica diferentes. No span visual (ordem direta e inversa) as crianças do sexo masculino obtiveram melhor desempenho, apesar de não ter diferenças significantes. Em relação à idade não houve diferença de retenção de estímulos. **Conclusão:** as crianças do sexo feminino, neste estudo, apresentaram tendência à melhor desempenho do span verbal e as crianças do sexo masculino tendência a melhor desempenho no span visual. No entanto, o estudo é limitado devido ao reduzido número de participantes na amostra.

**DESCRITORES:** Memória de Curto Prazo; Avaliação de Desempenho; Função Executiva

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