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THE IMPACT OF DIGITAL GAMES ON THE SHORT-TERM MEMORY OF UNIVERSITY STUDENTS

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ABSTRACT

This study aims to understand the impact of digital games on the short-term memory of male and female university students, assessing how digital games can impact cognitive performance and contribute to the development or deterioration of cognitive skills in short-term memory. With the increasing presence of digital games in the daily lives of young adults, it has become pertinent to understand how this exposure influences cognitive abilities, such as memory. The study was carried out as part of a larger research project coordinated by Professor Nuno Cravo Barata at the University of Fernando Pessoa. It used an experimental/laboratory, quantitative and cross-sectional approach. The sample consisted of 80 university students aged between 18 and 30 (M= 20,50; SD= 2,01), of whom 48,8% (N= 39) were male and 51,2% (N= 41) female. Tasks based on the Direct Digit Span, Indirect Digit Span and Verbal Span subtests were applied. The data collected from the questionnaires was organized and analysed using IBM SPSS Statistics vs. 29.0 (IBM Corp. released 2022, Armonk, NY, USA: IBM Corp.). The results of this study show that female students generally had higher cognitive performance than males, specifically in the Direct Digit Span stimulus, where the difference was statistically significant (p= 0,001). It was also found that the participants who responded faster obtained good results in the memory tests. In the future, this study contributes to a better understanding of the impact of digital games on cognitive functions, particularly short-term memory, while underlining the complexity of this relationship and the need for

multidimensional approaches in contemporary scientific research.

Keywords: Short-term Memory; University Students; Digital Games; Verbal Span; Direct Digit Span; Indirect Digit Span

1. INTRODUCTION

The present study analyzes the impact of the use of digital games on the short-term memory of university students, with the aim of understanding whether there are differences in cognitive performance in short-term memory between the male and female genders. Considering the significant increase in the presence of digital games in people's daily lives, particularly among university students, it is important to understand how this activity influences cognitive functions such as short-term memory (Granic, Lobel & Engels, 2014).

The relationship between digital games and short-term memory has aroused particular interest in Clinical and Health Psychology, due to its importance in the functional and academic lives of young adults (Green & Stutts, 2013).

Digital games are no longer exclusively recreational, but have taken on an important role in various areas of daily life. With the increase in the ability to access to the internet and technologies, the time spent playing digital games has increased significantly and several researchers have sought to understand how constant interaction with this type of stimuli can damage or enhance cognitive skills, such as concentration, short-term memory, reaction time and attention (Bediou et al., 2018; Boot et al., 2013). Short-term memory, which is essential for activities such as problem-solving, studying, understanding language and organizing thoughts, is particularly sensitive to external stimuli such as digital games (Baddeley, 2012; Cowan, 2017; Unsworth et al., 2015). Digital games that require decision-making and quick responses can affect this function, positively or negatively, depending on the type of game, time and intensity of use (Sala, Tatlidil & Gobet, 2018). In addition, digital games can have different impacts on cognitive functions between genders in the way they are used and their effects (Voyer & Voyer, 2014).
This study therefore includes a theoretical framework, an empirical study with a methodological description, a presentation and discussion of the results and, finally, a conclusion.

2. THEORETICAL FRAMEWORK

Memory is a cognitive function that allows knowledge to be encoded, stored and recalled. Memory functions in three stages: acquisition, consolidation and recall (Bear, Connors & Paradiso, 2017; Mourão & Melo 2011).

Memory is categorized into different types, each with specific functions and characteristics. For this study, it is important to focus on short-term memory, which is a temporary and active process that keeps information for short periods of time. It involves processes of repetition and recoding of acquired

knowledge and acts to convert information into long-term memory traces (Lopera, 2008; Padilla & Bajo, 1998). In the academic context, short-term memory plays an essential role in learning and the development of critical thinking, as it allows university students to synthesize information and relate theory and practice on a professional level (Nunes & Oliveira, 2010).

Assigning a single, precise meaning to the term "digital games" is a challenge, considering the multiplicity of concepts involved (Alves & Silva, 2020). In this study, the term is used to describe games with technological characteristics in general. According to Juul (2003), digital games combine game systems with narratives, standing out for their cultural impact and interactive character. The author defines them as formal systems governed by rules, different values and outcomes, in which the player must engage in order to obtain the expected results (Juul, 2003).

Digital games, once considered merely as forms of entertainment, are now recognized as educational. While some authors highlight their benefits for education and health, others point to possible negative impacts, such as unproductivity, violent behavior among young adults, and excessive distraction (Goulart, 2012).

Mendes (2006) mentions three essential characteristics of digital games: following a system of previously defined rules, the fact that they are recognized as a lucid activity and their inherent gameplay nature (Mendes, 2006). Involvement with these games can help improve cognitive skills, essentially problem-solving, efficient strategies and memory stimulation (Oliveira, 2007). In addition, the participation of players in groups promotes the exchange of experiences and the planning of strategies, stimulating executive functions such as organization, self-control and flexibility (Lent, 2013).

Relevant empirical evidence has been found to support this study. Zioga and colleagues (2024), in their research, analyzed cognitive abilities (verbal working memory, psychomotor speed, verbal short-term memory, visuospatial working memory, visuospatial short-term memory and attention) of young adult players in various types of digital games, and concluded that high levels of digital gaming proficiency developed improvements in working memory and visuospatial short-term memory, attention and psychomotor speed. They found that the different genres of action games showed a positive relationship with psychomotor speed and attention; puzzle games were positively associated with working memory and narrative games improved visuospatial short-term memory and verbal working memory. These results reflect that the type of game directly influences the cognitive abilities of each player (Zioga et al., 2024). According to the working memory model of Baddeley and Hitch (1974), as mentioned earlier in this study, digital games activate visual-spatial and phonological components, as well as training the executive control system by requiring skills cognitive such as making of decisions, coordination of multiple information and prioritizing new stimuli. This active and intensive processing gives players a short-term memory advantage (Baddeley & Hitch, 1974).

However, and no less importantly for this project, not all research shows that digital games have a positive

impact on short-term memory. According to Unsworth and colleagues (2015), not all players show benefits in short-term memory tasks, noting that all types of games have different consequences. In some situations, these negative effects, such as the development of ineffective strategies or cognitive overload, do not contribute to improvements in cognitive abilities outside the lucid context (Unsworth et al., 2015). Given the relevance of short-term memory in the academic context, especially in universities, digital games contribute to the positive reinforcement of university students. However, it is very important to integrate these digital games into the educational context in a careful and planned way, considering the duration, type, frequeney and cognitive profile of the students, in order to guarante the positive effects of each one (Unsworth et al., 2015).

Cognitive differences between genders have a neurobiological basis and are influenced by hormonal and social factors. The male brain tends to be more asymmetrical, with functions concentrated in one hemisphere, while the female brain has a more balanced distribution between the hemispheres, which can influence different cognitive strategies. Men perform better in visuospatial tasks, while women perform better lin lexical-verbal tasks. However, both genders can achieve the same results using different strategies (Lorber, 2005).

3. METHODOLOGY

3.1.Methods

The research was part of an ongoing project at the experimental laboratory of the Fernando Pessoa University: "Influence of digital games on the working memory of university students", coordinated by Professor Nuno Cravo Barata and approved by the Ethics Committee (FCHS/PI - 590/24-3). This study used a quantitative, experimental/laboratory and cross- sectional approach.

3.2.Participants

This research project includes criteria such as: university students aged 18 or over, students enrolled in universities, participants of both genders (male and female), participants who play digital games regularly or not and the type of sample is by snowball technique. For this project, a questionnaire was drawn up, and the collaboration of the participants was carried out for a month after its launch, i.e. 30 days for response. University students under the age of 18,

university students not enrolled in universities and participants whose gender identity did not fit the planned sample (male or female) were excluded. The sample was collected using the snowball sampling technique, in which participants were progressively included as long as they necessarily met the requirements previously established within the scope of the project. As shown below, the sample is made up of 80 university students aged between 18 and 30 (M= 20,50; Md= 20,00 and SD= 2,013), of whom 48,8% (N= 39) are male and
51,2% (N= 41) female.

3.3.Objectives

The general objective of this research is to analyze the influence of digital games on the short- term memory of male and female university students, assessing how digital games can impact cognitive performance and contribute to the development or deterioration of cognitive skills in short-term memory. With regard to the general objective, the following assumptions are made: P1. To compare gender differences in cognitive performance in short-term memory among users of digital games; P2. To check whether digital games have a different impact on short-term memory cognition depending on gender; P3. To relate the results obtained to cognitive theories.

3.4.Materials

A self-assessment scale was applied to the participants, based on a generic questionnaire on digital games, seeking to analyze whether or not the participant plays digital games (binary response: Yes/No). If the answer was positive, information was obtained on the intensity and frequency of this use, based on time average daily hours/minutes and days of the week. Consequently, an adapted version of the Wechsler Intelligence Scale for Adults (WAIS III/IV) was used (Afonso, 2002; Wechsler a. & Wechsler b., 2008). In addition, the Digit Span subtest was used for purposes of analysis in an experimental context. Digit span involves tasks in which the participant must observe and try to memorize numbers between 0 (zero) and 9 (nine). It consists of three parts: the Direct Digit Span, in which the test taker must repeat the sequence of numbers in the same order as they were presented; the Indirect Digit Span, in which the participant must repeat the sequence of numbers in reverse; and the Verbal Span, in which the subject must sort the numbers in ascending order. During the subtest, the participant is not given any time limit or feedback. The score is given according to the following criteria: 2 points if both answers are correct, 1 point if only one attempt is correct and 0 points if both fail, with 16 points being the maximum score achievable.

For this project, all the subtests were applied digitally and in sequence for use in SuperLab 5.0, which meant that a computerized version had to be created. This adaptation made it possible to remove human intervention in the presentation of the stimuli (difference in intonation, narrative rhythmic production, etc.) by including both the visual and auditory components of the numbers. The instrument was transformed into the A/B/C model, in which each version corresponds to the three types of activities mentioned. Following the presentation of each sequence, an answer box appeared where the participant entered the numbers, which were filled in with the help of a numeric keypad; the user typed in the numbers in the correct order, increasing the number of digits until they reached the next model and finished the test.

3.5.Statistical analysis

The statistical analysis was carried out using IBM SPSS Statistics (v.29.0), which allows for the efficient processing of quantitative data. To analyze the differences between genders, Student's t-test was used, which is suitable for comparing the means of independent groups. Verifying the normality and homogeneity of the variances ensured thel validity of the results. In addition, Pearson's correlation

coefficient (r) was used to measure the linear association between continuous variables such as reaction time and performance in the memory tests (Direct, Indirect and Verbal Span), with values between - 1 and +1, where 0 indicates no linear correlation.

4. RESULTS

By transposing the data from the SuperLab reports into the IMB SPSS 29.0 statistical software, tables of data and variables were constructed and results extracted in the form of statistical products from an experimental psychology project.

The student's t-test compared the male and female genders in the three stimuli: Direct Digit Span, Indirect Digit Span and Verbal Span. There was a statistically significant difference in performance on the Direct Digit Span stimulus (p= 0,001). Females performed better cognitively in the short-term memory task (M = 5,24 and SD= 0,767) than males (M= 4,05 and SD= 0,605). With regard to the Indirect Digit Span stimulus task, the results showed that the female gender performed better (M= 5,51 and SD = 0,637) than the male gender (M = 3,69 and SD = 0,655). The significance value (p= 0,595) was not statistically significant, which indicates that from a statistical point of view, although there are differences in the means, this is not robust enough to be considered significant. Finally, the Verbal Span stimulus activity also showed higher performance in females (M = 10,80 and SD = 1,289) compared to males (M = 9,23 and SD= 1,423) and this difference in means was not statistically significant (p = 0,527). We then analyzed the relationship between reaction time variables and duration of experience in the three stimuli: Direct Digit Span, Indirect Digit Span and Verbal Span. In general, there were negative and statistically significant correlations between the cognitive performance tasks and the reaction time and duration of experience variables. Specifically, it was found that faster reaction times were related to better cognitive performance in the Direct Digit Span (r= 0,532 and p= 0,001), Indirect Digit Span (r= 0,384 and p= 0,001) and Verbal Span (r= 0,251 and p= 0,001) stimuli. The results showed that participants who responded more quickly were more effective in the tasks assessed, indicating a possible cognitive advantage associated with the speed of information processing. At the same time, it was observed that the duration of the experience was significantly related to lower cognitive performance tasks in the Direct Digit Span (r= 0,367 and p= 0,001), Indirect Digit Span (r= 0,358 and p= 0,001) and Verbal Span (r= 0,251 and p= 0,025) stimuli.

5. DISCUSSION

Based on the results obtained, we are faced with data that offer relevant contributions for reflection on the effects of this practice on cognitive performance. It is therefore essential to point out that, in the Direct Digit Span stimulus, the female participants demonstrated a significantly higher cognitive performance than the male participants. This significance (p= 0,001) suggests that women have a greater ability to immediately reproduce and retain information in sequence, which is an important skill in short-term memory. This alignment with previous scientific studies reinforces the idea that this type of task, which requires rigorous repetition of numerical sequences, measures the capacity for immediate auditory storage, a central component of short-term memory (Baddeley, 2012; Cowan, 2017). As mentioned in the study

by Nunes and Oliveira (2010), who argue that the female gender, however little exposure to digital games compared to the male gender, the way in which female players engage in tasks, with focus, selective attention and strategies, can provide beneficial gains in specific cognitive functions, such as the immediate retention of numerical stimuli (Nunes & Oliveira, 2010).

With regard to the Indirect Digit Span and Verbal Span stimuli, the female gender also had better average results than the male gender, although these differences did not reach the threshold of statistical significance. Even so, the observed analysis is in line with what has been described in the literature, in which the female gender tends to perform slightly better cognitive functions than the male gender. In the study by Lober (2005), from a neurobiological point of view, there are functional and structural differences between the brains of men and women which may help to understand the differences in cognitive performance. Generally speaking, the male brain usually has greater cell weight and density, and shows greater functional asymmetry, which means that cognitive tasks are performed predominantly by a single cerebral hemisphere. In the female brain, cognitive skills are distributed across both hemispheres, thus promoting greater inter-hemispheric integration. These differences are largely influenced by sex hormones, which interact with the central nervous system via molecular receptors, preventing or providing neural connections. This process contributes to neural plasticity, i.e. the brain's ability to reorganize and adapt structurally over time. As a result, women perform better in verbal lexical tasks and men tend to be more proficient in visuospatial tasks (Lober, 2005).

As well as analyzing the comparison between the genders, this study also allowed us to explore the relationship between the participant’s reaction time and their cognitive performance in the different tasks. The results showed that the faster the reaction time, the higher the performance in memory tasks. This statistically significant relationship reinforces the idea implemented in the studies by Boot et al. (2008) and Zioga et al. (2024), which state that speed in processing information is related to increased cognitive efficiency (Boot et al., 2008; Zioga et al., 2024). Reaction time is defined as the time interval between the presentation of a stimulus (visual, auditory or sensory) and the start of the response, not including the movement itself (Schmidt & Wrisberg, 2001). It represents a reliable measure of the speed of cognitive processing and is directly related to information processing, perception and motor response capacity (Moreira, 2008). This phenomenon is particularly relevant to this study, as it involves various stimuli and quick decisions. The regular practice of digital games, especially action and strategy games, can train these skills, providing an increase in reaction time and consequently in cognitive functions related to short-term memory (Boot et al., 2008; Zioga et al., 2024). Thus, the results obtained in this study not only reinforee the importance of reaction time as a predictor of cognitive performance in short-term memory, but also validate ideas that the effectiveness of short-term memory maybe linked to the speed with which information is processed.

This interconnection provides positive evidence of the role of digital games in the executive functions of short-term memory. Also, according to the study conducted by Zioga and collaborators (2024), they also found that players with greater proficiency in digital games showed improvements in areas such as

working memory, visuospatial processing speeds and attention.

6. CONCLUSION

The results obtained in the study show that female university students demonstrate higher cognitive performance in the Direct Digit Span stimulus, reinforcing the hypothesis that there are differences in task solving, particularly in digital games, between the genders, possibly related to different levels of emotional involvement, distinct processing strategies, and neurobiological factors. Statistical analysis of the results also reveals that faster reaction times, regardless of gender, are related to superior cognitive performance in short-term memory tasks, suggesting a relationship between information retention effectiveness and cognitive agility in university students. Therefore, the premise that exposure to digital games, more specifically those involving cognitive skills, can provide players with improved processing of new information and specific benefits in executive functions.

Although the study presents highly relevant results, it is also important to note that there are some limitations, such as the number of participants, which, although adequate for preliminary statistical analysis, may limit the generalization of the data to other larger populations. In addition, given that this study is cross-sectional in nature, it is considered important to follow the subjects over a period of two years — a longitudinal study — to enable more accurate identification of causal relationships between cognitive performance in short-term memory and involvement with digital games.

Based on the conclusions of this research, it is recommended that digital games be integrated into educational contexts, in a manner that is aligned and consistent with pedagogical objectives, to stimulate cognitive skills in students such as short-term memory, attention, and decision-making; the promotion of digital literacy among students, encouraging equal participation of both genders in digital contexts; and training for teachers and technicians in psychology and education on the effective and conscious use of digital games as tools for cognitive stimulation.

Given the complexity of the topic and the results obtained, the following are suggested for future studies longitudinal research analyzing the effects of digital game use on long-term cognitive functions; consideration of gender identity profiles beyond the male-female binary, providing a more inclusive approach; an expansion of the sample to other areas of education, age groups, and geographical contexts, in order to ensure greater representativeness and generalization of the results; and the inclusion of cultural, motivational, and emotional variables that allow for moderating the relationship between digital games and cognitive performance. It is also important to note that continuing to explore gender-related issues is essential, not only from a biological point of view, but also taking into account the cultural and social factors that influence how each player relates to digital games. A more attentive and inclusive look may help to better understand the true impact of digital games on the cognitive development and mental health of young adults. Ultimately, understanding the impact of digital games on the short-term memory of university students is not only an academic curiosity, but also an opportunity for Clinical and Health Psychology to integrate new tools in promoting cognitive development in young adults.

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