Influence of Digital Games on the short-term memory of university students

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Abstract

Multiple recent studies, namely laboratory-based systematic review articles and applied or experimental research, have indicated the association, particularly in young or adult users, between results in measurements of short-term memory (STM) with the frequency and intensity of playing games using various forms of electronic support, globally known as digital games (DG). In this sense, we used an experimental study applied to the assessment of STM among university students, based on a comparative analysis between two groups, one of intensive users of digital games (IDG), and the other not (NIDG), statistically comparing the two results. The starting hypothesis holds that it is possible to statistically demonstrate that subjects who intensely use DG present, when tested in a laboratory context, higher results in STM tests. A self-assessment scale for the use of DG was used to define the experimental groups and, for data production, a subtest from the Wechsler Intelligence Scale for Adults measured for the Portuguese population, the digit span (or digit memory), experimentally adapted from a program produced using stimulus presentation software, SuperLab6. It was developed with 164 university students, with identical gender distribution, from a higher education institution. The results of the student t test indicated the presence of statistically significant differences between the groups. There are significant differences between the groups regarding STM according to the DOD. The potential applicability of the STM assessment program to different groups and objectives is concluded, particularly in an experimental context, and suggests its possible adoption as a Psychology tool in the areas of cognition.

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ABSTRACT

Multiple recent studies, namely laboratory-based systematic review articles and applied or experimental research, have indicated the association, particularly in young or adult users, between results in measurements of short-term memory (STM) with the frequency and intensity of playing games using various forms of electronic support, globally known as digital games (DG). In this sense, we used an experimental study applied to the assessment of STM among university students, based on a comparative analysis between two groups, one of intensive users of digital games (IDG), and the other not (NIDG), statistically comparing the two results. The starting hypothesis holds that it is possible to statistically demonstrate that subjects who intensely use DG present, when tested in a laboratory context, higher results in STM tests. A self-assessment scale for the use of DG was used to define the experimental groups and, for data production, a subtest from the Wechsler Intelligence Scale for Adults measured for the Portuguese population, the digit span (or digit memory), experimentally adapted from a program produced using stimulus presentation software, SuperLab6. It was developed with 164 university students, with identical gender distribution, from a higher education institution. The results of the student t test indicated the presence of statistically significant differences between the groups. There are significant differences between the groups regarding STM according to the DOD. The potential applicability of the STM assessment program to different groups and objectives is concluded, particularly in an experimental context, and suggests its possible adoption as a Psychology tool in the areas of cognition.

Keywords: short-term memory, digital games, higher education students, digit memory, superlab 6.

INTRODUCTION

Experienced gamers who spend several hours playing video games generally outperform non-gamers on measures of basic attention, memory, and performance. These differences may result from exposure to video games or may reflect other group differences between people who play and do not play video games. Recent research has suggested a causal relationship between playing action video games and improvements in a variety of visual, attention, and memory skills.[1]

In the wide diversity of genres and types of games, it stands out that some games can be called cognitive, as they propose the exercise of skills cognitive, which tends to contribute to the students learning process to the extent that education aims to develop the brain through stimulation and acquisition of knowledge that enhance and transform the way the brain works, leading players to have better performance also in other school activities that require the use these same cognitive abilities. Cognitive games exercise significantly the aspects linked to cognition, that is, they challenge the player to use elements such as logical reasoning, memory, attention, problem solving, among others, converging aspects of playfulness, pleasure, joy and fun present in digital games.[2]

Cognitive abilities can be understood as the capabilities that make the subject competent and allow him to interact symbolically with the middle. These skills allow, for example, discriminate objects, identify and classify concepts, raise problems, apply rules and solve problems, and provide the construction and continuous structuring of mental processes.[3]

Not referring to the intersection between cognitive skills and games, we use the term cognitive games, considering that games referred to in this way have common characteristics games, but they receive this name because involve more cognitive skills. Many games that we can classify as cognitive have not been developed with the aim of working on these skills, but can be considered as such due to their challenges and dynamics.[3,4] From this we can distinguish two main types of cognitive games: (i) Challenge games: present problems that mobilize the player to think, raise hypotheses, experiment, plan, test, perform calculations. In this way, they contribute with the improvement of logical reasoning, visual perception and attention; (ii) Opposition games: present different formats and objectives; of, they involve the participation of at least two players, the exercise strategy and logical reasoning to beat the opponent or solve the challenge presented.

In the same sense, several authors argue that working memory is considered a type of transient memory and operational, keep information available for use during the reasoning and understanding, having the function not only of retaining information, but also to process it.[4]

According to Cosenza and Guerra[4], the working memory has the function of retaining transient information and can also process and transform them if necessary. This information is processed together with sounds, images, thoughts, and can be used to solve problems, reason, interpret statements or understand something. In this sense, the working memory is very important in learning, as it is what makes the connection between information received by sensory means and long-term memory term, supporting other more complex cognitive activities, such as reading, calculation, problem solving.

Action video games modify visual selective attention and consequently short-term memory. Current research has sought to replicate and extend these results by examining differences between experts and non-gamers and the effects of video game play on tasks that encompass a wide range of cognitive abilities, including attention, memory, and executive control. Therefore, some studies indicate that video game players and non-gamers differed in several basic cognitive abilities: experts could track objects that moved at greater speeds, better detect changes in objects stored in short-term visual memory, switch more quickly from one task to another and mentally rotated objects more efficiently.[5,6,7] In this sense, extensive video game practice points to a substantial improvement in the performance of non-gamers in most cognitive tasks.

In view of the behavioural impact generated by games, researchers from around the world, but mainly from the United States, began to study the impact that video games could have on various cognitive processes, initially perception.[8] Even in games that are currently considered simple, such as Pacman® and Space Fortress®, researchers have found important behavioural changes generated by the video game.[9] Recent research suggests that video games, even when played for a relatively short period of time, promote improvements in the performance of video game players (VGP) in a large number of visual perception, memory and attention tasks. In fact, several studies suggest that participants who were exposed to 10 hours or more of video games show improvement in several laboratory tasks that, apparently, were different from the video game itself, leading them to propose that the experience of playing video games improves basic

cognitive functions (such as spatial skills), which can be generalized to new tasks and stimuli. [1,6,7,10,11]

Furthermore, in some investigations with video games and cognitive tasks, games were associated with attentional benefits, including improvements in attention, optimization of attention resources, integration between attentional and sensory areas-motor and improvements in selective attention and peripheral visual attention.[7,12] VGPs may also benefit from enhanced visuospatial working memory capacity according to Boot and colleagues, who found that JVJs outperformed non-video gamers (NVG) on several visuospatial working memory tasks such as multiple object tracking, mental rotation and change detection.[13] Improvements in working memory and short-term memory have similarly been found following video game training in experimental versus control group research designs.[13,14] This finding is consistent with other studies that suggest that even short video game training paradigms can improve functions related to cognitive control over long periods, such as reading skills in dyslexic children[15] and, more particularly, memory. work and short term.[12]

On the other hand, it is recognized that prolonged exposure to video games can promote significant psychological changes and the likelihood of an increased incidence of psychopathology for those who use video games intensively.[15,16,17,18,19,20,21]

In the same sense, multiple recent studies, namely systematic review articles[22], laboratory-based and applied research,[23] or experimental in nature,[14] have indicated the association, particularly in young or adult users, between the results in short-term memory measurements with the frequency and intensity of playing games using various forms of electronic support, globally known as digital games (DG).

In terms of a possible generic definition, “game”, within the scope of human social activity, corresponds to voluntary, individual or collective behaviour, supported by reasoning and actions based on rules and quantifiable objectives that include stages and/or conclusions, involving one or more subjects in challenge or competitive opposition.[23] The same assumptions apply to DG, although with additional terms, given that one of the main opponents and all other recreational activities are managed by computer programs (software) and executed on physical equipment supports (hardware) under computational bases. Based on multiple programming languages, DGs have been used in three categories of equipment: video games, personal computers and mobile equipment or devices.

The common characteristic line between them results in four essential determinants, namely: i) visual and/or auditory information mostly on screen, ii) varied competitive intensity, iii) change in conditions or levels of action, individual or collective games under the forms of player(s)/equipment(s) and iv) player(s) vs. equipment(s), with equipment(s) being understood here as a combination of software and hardware in product(s). This definition of DG, based on physical-intellectual responses to audiovisual stimuli, cognitive-based mental actions, challenges in individual or social collective bases, or simply in the form of a pastime, or even as a therapeutic resource, it is a common basis for human interaction in recent decades.

It is observed that adults and young adults, less prone to digital info-exclusion and more capable of procedural speed, are cognitively qualified to not only integrate into these technological activities but also prefer to interact through them. This also tends to be observed[24] among higher education students and may even constitute a working tool for improving communication and learning skills. In a psychopedagogical study on a sample of

higher education students that focuses on the thematic axis explored (relationship between short-term memory and the practice of games, particularly digital ones), but oriented towards administration traditional use of a cognitive assessment instrument not supported by computer support, the following results were presented: reduced rate of DG practice on the game practice self-assessment scale; in the cognitive framework, low retention rate of recent information.[25]

Still according to the same work, although small, and under an initial hypothesis raised, there is a statistical demonstration that playing games contributes to short-term memory. The high interest shown by the participants on the topic is also highlighted, leading to the prospective analysis that the integration of this project in the form of sensory stimulation based on computer support (with a lower degree of intervention between participants in the automatisms of written recording of the respective answers) could contribute to students' cognitive-based mental processing with possible impacts on short-term memory. Framed within the software used to generate and execute psychological experiments on a computer, SuperLab (v.6) constitutes a product within the options available today, present for around 30 years in experimental psychology. From a review of the available literature it is possible to determine the existence of research carried out and published internationally using SuperLab.[26] This software has allowed a field of investigation and analysis, in Psychology and Neuropsychology, worked in an experimental way on themes or areas of incidence generally centred on the fields of cognition or disturbances in the activities and respective connections of brain areas (e.g., memories, words, letters, objects, emotions, expressions, facial recognition, communication, speech, language, semantics, verbal fluency, anxiety disorders). Research with methodological and instrumental relevance for contextualizing the current study regarding the use of oral and visual electronic stimuli via the SuperLab software, and which is based on the reference to a related cognitive function assessment measure with the flexibility of information processing associated with calculation capacity, two works in the Archives of Clinical Neuropsychology appear in ScienceDirect. The first focused on a revised version of the paced auditory attention test with visual and auditory computer presentation.[27] The second applied to the diagnosis of mental illness based on a WAIS model supported by research centred on experimental groups.[28]

The present investigation is scientifically anchored under the following working premise: i) existence of a possible relationship between short-term memory and the intensive practice of DG in groups of higher education students; ii) the incidence in the research results on the short-term memory measurement variable does not allude to or evaluate data of a sociological nature relating to gender/sex, age, year of course, or other independent or work variable with sociometric implications, but is solely determined by DG's intensive practical self-assessment criterion for forming experimental groups; iii) with unique characteristics, without accommodating a continuity study, it corresponds to an experimental psychology project structured around stimulus presentation software specifically created for the purpose of recording, in order to assist in responding to the terms conditions of the generic hypothesis formulated: observation, or not, of a statistical difference in the results achieved between groups of students on the relationship between short-term memory and the use of DG.

OBJECTIVES

The construction of a sustained experience in the SuperLab6 computer program seeks to evaluate, through a population sample of university students constituted for this purpose

(obtained through a self-assessment scale of the practice of games in DG modalities), a strong use (≥1 hour daily, with 7 or more hours of play per week in the last year) and another not (who played 1 hour or less per week in the same time interval), on a variable measuring cognitive function, specifically short-term memory, through the results of applying an assessment instrument, the digit span (or digit memory), comparing its results.

Therefore, the following hypothesis is considered, namely: Subjects in the sample group from a population of university students who frequently use (≥1 hour daily) digital games produce higher results on a dependent measurement variable of short-term memory (digit span) than subjects from another group in the sample who usually do not play with the same frequency or intensity. The data observed in the experimental procedure will be treated within the framework of hypotheses, through a statistical procedure that helps in making a decision between two or more hypotheses (null hypothesis H0, or alternative hypothesis H1), allowing the null hypothesis (H0) to be accepted or rejected, namely, H0: there is no statistical (significant) difference between groups; H1: there is a statistical difference between groups.

METHOD

Design

This quantitative, cross-sectional and laboratory/experimental study was applied to the assessment of short-term memory (STM) among university students, based on a comparative analysis between two groups, one of intensive users of digital games (IDG), and another non-intensive user of digital games (NIDG), statistically comparing the two results. The starting hypothesis states that it is possible to statistically demonstrate that subjects who intensely use DG present, when tested in a laboratory context, higher results in STM tests.

Participants

The sample is made up of 164 university students, with identical gender distribution, from a higher education institution in Porto, Portugal, with an average age of 21.50 (SD=2.93), with 45% of the gender female and 55% male. Two research groups were created, one of intensive users of digital games (IDG), and the other of non-intensive users of digital games (NIDG) both with 82 university students. The desired homogeneity in the selection of the two groups of candidates or proponents in relation to the outlined sample was potentially ensured by the prior selection arising from the initial individual self-assessment questionnaire on the intensity of DG use. This procedure also reduced the potential expectation of non-response bias, since the selected participants collaborated in an informed manner within the framework of the research determinants. Specific control over the constitution of the sample tended to mitigate the emergence of parasitic variables or significant outliers, also promoting greater avoidance of type I errors in the testing of hypotheses.

Material

A self-assessment scale for the use of DGs was used, created for this purpose based on a generic questionnaire on rule games applied to the problem, seeking to observe whether the respondent uses them (yes/no) and, if so, which its frequency and intensity (days of the week and average daily number of hours/minutes).

We also used the adaptation of the Wechsler Intelligence Scale for Adults (WAIS III/IV).[30,31,32]

The Digit Span/Digit Memory subtest was used for research purposes in an experimental context. The Wechsler Adult Intelligence Scale[23,24,25] is a comprehensive clinical instrument used to assess the intellectual abilities of adolescents and older adults (≥16 ≤ 90 years), providing verbal and nonverbal intellectual scores with based on individual performance. It is composed of subtests that assess simultaneous and sequential processing, attention, and concentration; includes two main subtests, digit span (auditory processing, attention/concentration, mental manipulation) and arithmetic; It also includes, in addition, a subtest for sequences of letters and numbers.

The digit span corresponds to a task in which the person being evaluated is asked to operate with numbers, from 0 (zero) to 9 (nine). Consisting of three parts within the framework of the usual application methodology (Digit Span, subtest of The Wechsler Adult Intelligence Scale - WAIS), in the direct order digits (DOD) the subject is read a sequence of numbers which he must repeat in same order; in reverse order digits (ROD), the person being evaluated is read a sequence of numbers that they must repeat in reverse order; In the sequencing digits (SD), the person being evaluated must repeat the numbers presented in ascending order. In the context of assessing cognitive or intellectual functioning, the application of the test has no time limit and there is no feedback. For quotation, in each element you can obtain 0, 1 or 2 points, according to the following criteria, namely, 2 points if the subject correctly perform both tests, 1 point if it is an exercise, 0 points if you do not complete any of the tests, with 16 points being the maximum score achievable.

It also includes another result, Major Sequence of DOD/ROD/SD, referring to the number of digits recalled in the last test with a score of 1 (usually counted, for a maximum total of 9, but not in the version of the present study). In the original format, the test ends when the subject obtains 0 (zero) points in the two tests of an element; This procedure was not included for the experiment, with all subtest proposals being presented sequentially, with subsequent adjustments during data verification and reconciliation. The same was determined to calculate the number of digits recalled in the last test in which 1 (one) point or more were achieved (signals SDOD, SROD, SSD), not being used for the outlined experiment. To use the instrument in a laboratory context of experimental incidence, particularly in light of the SuperLab6 computer support, an adaptation of the technical and methodological procedures was created in the form of digital production. Within the framework of a prior procedural delimitation, in addition to the auditory component, visual annotations of the indicated numbers were also inserted in order to remove human intervention (difference in intonation, narrative rhythmic production, etc.), promoting the greatest possible automatism. -vel in experimental application. The instrument, divided into the original procedure under the DOD/ROD/SD tests, was transformed into models A/B/C. With written and spoken sequences of numbers being presented, on the page following each presentation an answer box appears, the filling of which is assisted by the numeric keypad; users enter the numbers in the desired order, increasing the number of digits until reaching the next model and finishing the test.

Statistical analysis

The study outlined uses sampling of a non-probabilistic nature (for convenience, in the form of intentional/rational selection on the accessible population in a random sample of this group of students. The measurements are direct, with the data not being transformed into scale variables or intervals referring, for example, to the number of hours of contact with DG or the age groups that use them, constituting a “non-criterion” notation (e.g., correlation r between

variables) in the research production. For statistical purposes based on the deviation from the average, results on STM levels relative to a possible previous average compared from previous studies were not taken into account. In the outlined experimental context, the assumption of n≥30 research subjects would allow the resource to the calculation of a student regarding the difference between groups based on the study of the homogeneity of the sample.

Taking the previous assumptions in H1, there would be an effect of the groups on the means if the tstudent test demonstrates that the group of DG users has an effect on the results of the assessment instrument.

RESULTS

By transposing data from Superlab6 reports into IBM® SPSS® 26.0 computer statistical support (commonly referred to as "SPSS"), tables of data and variables were created, and results were extracted in the form of statistical products from of an experimental psychology project.

After investigation on the digit span instrument based on models produced using stimulus presentation software, it was found that the IJD group always scores higher in the direct order digits (DOD) (IDG: $\bar{x}$ = 9, 95, σ = 1.59; NIDG: $\bar{x}$ = 7.45, σ = 1.27), followed by the reverse order digits (ROD) (IDG: $\bar{x}$ = 8.90, σ = 1.30; NIDG: $\bar{x}$ = 7.10, σ = 1.35) and the sequencing digits (SD) (IDG: $\bar{x}$ = 7.80, σ = 1.32; NIDG: $\bar{x}$ = 6.00, σ = 1.30).

Thus, the differences in the presence of short-term memory scores were statistically significant. The results of the student t test indicated the presence of statistically significant differences between the groups. There are significant differences between the groups regarding MCP according to the DOD [t164 = 1.75; p =.05], ROD [t164 =-5.58; p =.00] and SD [t164 =-4.65; p =.00].

In short, we can assume that the IDG present superior results in assessing short-term memory when compared to the NIDG group. The differences found support and demonstrate what was objectively assessed.

DISCUSSION

In this study, in comparison with IDG and NIDG, differences were found in the task performed, which seem to predict comparative changes in the research groups regarding short-term memory, perhaps allowing for the prediction of better cognitive performance in short-term memory in key regions of the cortex. responsible for visual processing, attention and memory.[14,6,13,15,12,7] With a specific experimental instrument applied to a sample of two groups of university students, which showed good receptivity as a voluntary collaboration activity in an experiment in a laboratory context, the data obtained determine statistical relevance between subjects who intensely use video games in the STM results compared to the group of those who do not use them at all or little, which is in line with the empirical proof of the main working hypothesis.

Preliminary data resulting from comparable studies on STM in university teaching and game practice had already empirically supported the occurrence of results that identified differences between groups similar to those of the present investigation. In conclusion, the authors, based on the same analytical principles, but anchored by a non-experimental methodology, maintain

that the data obtained demonstrate, indirectly, the hypothesis of a statistically demonstrable connection, namely through complementary work.[15,17,21,22]

The differences found in both groups were consistent with an association between video games and cognitive abilities that appear to involve greater response and working memory training. Therefore, the results revealed that participants, from both groups, present notable differences according to the effectiveness of the presence of video games in their daily lives, which is in line with various studies.[6,14,10,16,7,21,24,25]

Based on these findings and the objectives proposed in this empirical study, it is confirmed that there are differences between IDG and NIDG participants, which is consistent with previous research.[18,6,14,13,16,12,7]

The use of digital games versus cognitive games may have high potential in the educational/school context. It reveals contributions not only to the exercise of cognitive skills, but also creates an environment rich in social interaction that allows you to work on social aspects related to attitudinal content and contributes to the subject's motivation.

In future investigations, and as a limitation of the present study, it is suggested to replicate the study with more robust samples and at different developmental stages that allow for more precise generalization of the results. At the same time, the present situation will allow us to analyze in a more expressive way, the differences observed in these subjects regarding the impact of digital games on short-term memory.

CONCLUSION

Overall, even considering the correlational nature of the cross-sectional data, the current findings are consistent with the fact that video games appear to be associated with better performance on cognitive tests involving response inhibition and working memory.

The results seem to predict that there is a clear possibility that video games could provide a cognitive training experience with measurable neurocognitive effects. Despite evidence that the use of digital games can improve ability to working memory, it is necessary to deepen further studies in the area seeking to identify the aspects that contribute to this, which conditions could be better observed, the type of challenge and game mechanics that contribute most, among other aspects that would need to be further explored to guide pedagogical practices at school.

However, it seems important that future investigations allow researchers to test the longitudinal effects of video games in improving response inhibition, working memory and other cognitive functions. The longitudinal design of the study will allow testing, within participants, the correlates of accumulated video game practice over the years. using methods such as cross-correlations or causal inference. It is also suggested to use the Emergency Response and Psychological Adjustment Scale (ERPAS) to assess cognitive and emotional responses under stress, with parallels in digital gaming contexts.[33]

Therefore, and imbued with an exploratory nature, the research also did not incorporate into the experimental procedures the inclusion of other possible observations in the adopted categories, or in others to be considered in the research design, such as association effects or relationships with gender variables, age, year and pre-graduate course attended, as well as all

those that allowed refining procedures and enhancing particular problems.

The experimental psychology exercise took place with a marked interest on the part of the study groups, and it was not difficult to admit the reasoning that associates the greatest desire of young adult populations in operating and interacting with computer-based technologies. The problem centred on DG also did not involve any interpretative resistance regarding the objectives determined among the respondents, namely those of a cognitive nature, when associated with a game perspective or simple logical challenges of reasoning and responses.

In addition to these conclusions, the computer program produced offers adaptive capabilities to the most varied populations in all areas of Psychology, with an integrative contribution to experimental observations or designs based on quasi-experimental methodology, whenever the use of an information collection instrument to STM measurement respects the temporary storage of information related to numbers in a determined order. Due to its general potential, its use and improvement are recommended in the context of future experimental investigations based on stimulus presentation software on STM between subjects and groups in various modalities of assessment or psychological intervention, with natural inclusion, among others, of clinical, social, development, education, health or neuropsychology areas.

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