THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 12 Issue 10

RESEARCH ARTICLE

Investigation of the Relationships Between Digital Games and Neuropsychological Test Scores and Cognitive Functions

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OPEN ACCESS

PUBLISHED
30 October 2024

CITATION
Gunuc, S. and Koylu, EO., 2024. Investigation of the Relationships Between Digital Games and Neuropsychological Test Scores and Cognitive Functions. Medical Research Archives, [online] 12(10). https://doi.org/10.18103/mra.v12i10.6001

DOI
https://doi.org/10.18103/mra.v12i10.6001

ISSN
2375-1924

ABSTRACT

This study aimed to examine the relationships between digital games and neuropsychological test scores (card sorting, verbal memory and digit span tests). The study was designed using the descriptive cross-sectional research method. Data were collected from a total of 117 volunteering university students at a state university. Of all the participants, 66.9% of them were women, and 33.1% were men. The mean age of the participants was calculated as 21.3 years. In the study, demographic variables were determined, and data on games were collected from the participants. In addition within the scope of neuropsychological tests, Wisconsin Card Sorting Test, Öktem Verbal Memory Processes Test and Digit Span Test were used. The results of the study revealed that the neuropsychological test scores did not show a significant difference in terms of digital game players/non-players and game types.

Keywords: Neuropsychological test; Digital game, Video game, Cognitive functions

Introduction

Today, the number of users of digital games is increasing worldwide thanks to the different options and wide range that these games offer to individuals of all ages. With respect to their primary production purposes, digital games can be classified as games produced for "entertainment", "education", "skill", "electronic-sports", "simple content" and "exercise". Depending on the purpose of their production, games such as educational and skill teaching are also referred to as serious games. Moreover, a digital game produced for any production purpose may simultaneously include other production features such as entertainment or educational purposes.[1,2] Digital games can be classified based on their content into genres such as action (e.g. war, fighting or shooting games, role-playing, simulation, strategy, puzzle and sports games.[3]

Although the benefits and harms of digital games vary depending on their content and purpose, the main benefits of especially educational or serious digital games include entertainment and spending pleasant time, hand-eye coordination, language development, social development, attention development as well as many other benefits.[3] Games, like digital games, which include many benefits and almost no harms, are serious and educational types of games. On the other hand, many digital games may result in addiction as well as in many physical, social and psychological negativities,[3,4] and the benefit-harm balance in using these games is open to debate.

Features of digital games include elements like fantasy, curiosity, role-playing, entertainment, rules, goals, competition/challenge, problem solving and interaction. These elements are at different levels in different game types. It is claimed that digital games, especially some types, contribute to motivation, learning, executive functions and cognitive performance.[5-7] Some studies also demonstrated that digital games can improve spatial skills such as mental rotation and spatial visualization.[8]

In the literature, it is pointed out that different types of digital games contribute to cognitive functions and skills. For instance, strategy games are claimed to contribute to cognitive development as well as to be beneficial for the working memory and control skills and possibly for long-term memory retrieval. It is also argued that role-playing games improve retrieval from long-term memory, reasoning, supervisory abilities, and working memory. Online games involving a massive number of players are said to improve response speed, reasoning, supervisory abilities and working memory within the context of social interactions.[9]

Some studies revealed that action games are effective on cognitive functions, especially in terms of visual perception, top-down attention and spatial cognition, mental rotation skills, multitasking, inhibition and verbal cognition.[10] On the other hand, there are studies arguing that action games provide improvement in perceptual and attention abilities yet do not lead to an improvement or change in executive function.[11]

It is claimed that playing an action game requires remembering a control scheme, adapting to changes in difficulty and making quick decisions. It is also known that hand-eye coordination is required in most action games. The speed at which a player's memory works in a game determines his or her performance, and players who play with the intention of advancing or winning also need fast data processing. Although certain games may contribute more to a skill than other games (e.g. visual attention in shooter games), memory-related skills like memorizing a rule set are fundamental for all players.[12] Consequently, memory, decision-making, speed and motor coordination are intensively applied in action games,[12] which gives rise to the claim and debate that executive functions, skills or abilities related to the functions used will develop further.

In general, digital games are claimed in some studies to contribute to executive functions as they often involve repetitive practice and increasingly challenging activities.[13-15] Some argue that there is no such contribution or that it is very limited if any.[16-18] In some other studies, it is pointed out that digital action games contribute to a few skills such as cognitive and visual selective attention and visual short-term memory.[16,19-22]

In the literature, the effects of digital games on cognitive functions were examined in different age groups. There are studies claiming that digital games improve cognitive achievement and cognitive functions in children.[23,24] In some studies, it was seen that there were contributions to cognitive functions in young people[25,26] as well as in adults.[27] The variable of age is an important factor in terms of brain development, especially in cases where cognitive processes and cognitive performance such as executive functions are evaluated. Executive functions refer to a set of related cognitive processes that allow planning, monitoring and controlling of cognition, behavior and emotions to remain goal-oriented. Executive functions first emerge in early childhood and continue to develop throughout adolescence into early adulthood.[28,29]

In real life, although physical (or traditional) games are seen as an important function in cognitive development and learning,[30,31] the fact that a similar situation is discussed for digital games raises some debates. While the benefits of educational or serious digital games are more obvious and indisputable, the main debates continue in terms of digital games like action-shooters, which have addictive and inappropriate content (those containing weapons, blood, violence and sexuality).[3] Because games like action-war contain inappropriate content and addictive elements, the alleged contribution of these games to some cognitive skills may lead to the ignorance of addiction and other negative effects that may develop in the individual. For this reason, the findings regarding whether cognition scores differ with respect to the digital games examined in this study will make an important contribution to the literature.

In the literature, the general view in studies like the meta-analysis study conducted by Reynaldo and colleagues[32] is that digital games such as action and strategy improve cognitive abilities and performance. On the other hand, there are also studies showing that digital games do not make a significant difference on cognitive functions. The relationship of digital games in general and action games in particular (like non-educational games) with individuals' cognitive functions and performance has not yet been discussed. In this respect, this study aimed to examine the relationships between digital games and neuropsychological test scores (card sorting, verbal memory and digit span tests).

Method

RESEARCH DESIGN

This study was designed using the Descriptive Cross-Sectional Research method within the scope of a descriptive or relational study as it aimed to reveal the relationships or interactions between events or variables. Descriptive cross-sectional research method is one used to describe the situation of phenomena or relationships between phenomena at a specific time.[33] In this respect, in the study, neuropsychological test scores related to digital games were compared, and the relationships were described.

PARTICIPANTS

In the study, the "convenience sampling" method was preferred in terms of accessibility, and the data were collected at a state university. The study was conducted with 117 volunteering university students. Of all the participants, 66.9% of them were women, and 33.1% were men. The mean age of the participants was calculated as 21.3 years.

DATA COLLECTION TOOLS

In the study, demographic variables (gender and age) were determined and data on digital games were collected from the participants. In addition, within the scope of neuropsychological tests, Wisconsin Card Sorting Test, Öktem Verbal Memory Processes Test and Digit Span Test were used.

Wisconsin Card Sorting Test (WCST): The Turkish standardization of the Wisconsin Card Sorting Test[34,35] was done by Karakaş and colleagues.[36] WCST included two card decks made up of four stimulus cards and 64 response cards (ordered by color, shape and number). In this study, the computer version of the 128-card WCST was used. Additionally, in the study, the parameters of "total error", "perseverative responses", "non-perseverative errors" and "Failure to maintain set" were used in the evaluation of WCST. This test, developed to measure abstraction, conceptualization, mental flexibility, problem solving, category creation and category changing skills, also measures complex attention skills.

Öktem Verbal Memory Processes Test: The test was developed by Öktem Tanör[37] for the multi-factorial investigation of verbal learning and memory. Immediate memory includes the processes of learning, retention and retrieval. The test, which evaluates the ability to learn verbal material and to recall and recognize the learned material from memory, is used to evaluate neurological and psychiatric disorders. This test is conducted on face-to-face basis individually with each participant, and it takes approximately 40-45 minutes to complete the test. In this study, the sub-parameters of the Verbal Memory Test, which were immediate memory, total learning and long-term memory (spontaneous recall), were used.

Digit Span Test: WMS-R Digit Span, which was developed by Wechsler[38], was one of the sub-tests of the Wechsler Independence Scale. The Turkish adaptation study was carried out by Karakaş[39]. It was a neuropsychological test which was used as a test of simple and complex attention and/or working memory and which was claimed to be affected by stress and anxiety. Digit span consists of two parts: Digit span forward and digit span backward. With this, immediate memory (forward) and working memory (backward) are measured. Basically, maintaining attention is measured with digit span forward, and working memory is measured with digit span backward.

DATA COLLECTION

Appointments were made with the students for the measurements, and face-to-face interviews were held at students' convenient times. The interview with each student lasted at least 45 minutes. In order to collect data from each student, the researcher used the paper-pencil method for the application of the demographic information form, Öktem Verbal Memory Test and Digit Span Test, respectively, and the researcher used a computer software for the application of WCST. During the data collection process regarding the Öktem verbal memory test and digit span test, the researcher collected data by applying them separately to each participant. The data collection process lasted approximately 3 months.

DATA ANALYSIS AND ETHICS

The data collected both with the paper-pencil technique and computer software were entered into the SPSS 21.0 package program and checked, and whether there were any missing data and outliers was examined in order to make the analyses more reliable. The assumptions for each analysis were evaluated, and the distribution of the data was examined with kurtosis-skewness, histogram, P-P and Q-Q values and graphs. As a result of the examinations, it was seen that the data showed a normal distribution, and t-test, one of parametric tests, was used. In the analyses where there were not enough data per category, Kurskal Wallis, a non-parametric test, was used. In addition, descriptive statistics such as frequency and percentage were used as well. Ethics committee approval for the research was received from the Non-Interventional Clinical Research Ethics Committee (Decision No: 422; Research No: 402) at Izmir Bakırçay University.

Results

In this study, neuropsychological tests such as verbal memory, digit span and card sorting were used. The data collected with card sorting were obtained through the parameters of "total error", "perseverative responses", "non-perseverative errors" and "failure to maintain set"; the data collected with the digit span test were obtained through the parameters of "digit span forward" and digit span backward"; and the data collected with the verbal memory test were obtained through the parameters of "immediate memory", "total learning" and "long-term memory (spontaneous recall)". The analyses were conducted using these parameters.

Findings were obtained primarily as a result of the descriptive analyses. According to the descriptive statistics, 39.5% (f:49) of the participants stated that they played digital games, while 60.5% (f:75) reported that they did not play digital games. In addition, each of the participants who played digital games had been playing for at least the last six months. The average weekly gaming time of the participants was calculated as 5.33 hours. Of all the participants who played digital games, 45 (36.3%) reported that their primary and most-played game type belonged to four different categories. The findings are presented in Table 1.

Table 1. Distribution of the gamers with respect to the game types

Game Type	f	%
Puzzle-Entertainment	8	6,5
War-Action-RPG*	17	13,7
Sport-Race	6	4,8
Strategy	11	8,9
Others	3	2,4

*Role-Playing Game

As seen in Table 1, most of the participants who played digital games stated that they played war/ action and strategy games. When the participants who played digital games and those who did not were compared with respect to the three neuropsychological test scores, the t-test findings in Table 2 were obtained.

Table 2. Comparison of the Neuropsychological Test Scores with Respect to Playing Digital Game or not

Variable		n	Mean	Sd.	Std. Err. M.	t	Df	*p*
Card Sorting	Playing Digital Game							
Total error	Yes	49	25,204	20,298	,137	-,854	122	,395
	No	75	28,293	19,302	,144			
Perseverative responses	Yes	49	13,286	9,531	,137	-1,621	122	,108
	No	75	16,787	13,003	,144			
Non-perseverative errors	Yes	49	12,857	13,200	,137	-,225	122	,822
	No	75	13,320	9,679	,144			
Failure to maintain set	Yes	49	1,041	1,756	,137	,527	122	,599
	No	75	,907	1,080	,144			
Digit Span	Playing Digital Game							
Digit span forward	Yes	48	6,229	1,189	,137	-,424	121	,673
Digit span backward	No	75	6,320	1,141	,144			
	Yes	48	4,625	,937	,137	-,931	121	,354
	No	75	4,800	1,065	,144			
Verbal Memory	Playing Digital Game							
Immediate memory	Yes	49	5,816	1,629	,137	-,356	122	,723
	No	75	5,920	1,558	,144			
Total learning	Yes	49	111,184	14,015	,137	1,041	122	,300
	No	75	108,373	15,130	,144			
Long-term memory (spontaneous recall)	Yes	49	13,225	1,598	,137	,161	122	,872
	No	75	13,173	1,804	,144			

When Table 2 is examined, it is seen that no neuropsychological test scores showed a significant difference (p>.05) between the participants who played digital games and those who did not. As sufficient numbers could not be obtained in each game type, the neuropsychological test scores were examined according to four different game types by using Kruskal Wallis, one of non-parametric tests, and the findings in Table 3 were obtained.

Table 3. Comparison of the Neuropsychological Test Scores with Respect to Four Different Game Types

	Game Type	N	Mean Rank	Chi-Square	Df	p
Total error	Puzzle-Entertainment	7	9,21	8,763	3	.033
	War-Action-RPG	18	23,11			
	Sport-Race	6	23,50			
	Strategy	11	25,59			
Perseverative responses	Puzzle-Entertainment	7	12,21	5,235	3	.155
	War-Action-RPG	18	22,28			
	Sport-Race	6	23,33			
	Strategy	11	25,14			
Non-perseverative errors	Puzzle-Entertainment	7	9,29	8,622	3	.035
	War-Action-RPG	18	23,89			
	Sport-Race	6	22,25			
	Strategy	11	24,95			
Failure to maintain set	Puzzle-Entertainment	7	15,29	3,521	3	.318
	War-Action-RPG	18	22,33			
	Sport-Race	6	26,17			
	Strategy	11	21,55			
Digit span forward	Puzzle-Entertainment	7	14,14	7,521	3	.057
	War-Action-RPG	18	22,42			
	Sport-Race	6	30,42			
	Strategy	10	17,60			
Digit span backward	Puzzle-Entertainment	7	16,57	1,924	3	.588
	War-Action-RPG	18	21,75			
	Sport-Race	6	25,08			
	Strategy	10	20,30			
Immediate memory	Puzzle-Entertainment	7	23,36	1,408	3	.704
	War-Action-RPG	18	20,47			
	Sport-Race	6	25,92			
	Strategy	11	19,59			
Total learning	Puzzle-Entertainment	7	28,36	4,989	3	.173
	War-Action-RPG	18	21,03			
	Sport-Race	6	25,08			
	Strategy	11	15,95			
Long-term memory (spontaneous recall)	Puzzle-Entertainment	7	27,64	4,831	3	.185
	War-Action-RPG	18	18,86			
	Sport-Race	6	27,42			
	Strategy	11	18,68			

When Table 3 is examined, it is seen that there was a significant difference only in terms of the parameters of non-perseverative errors and total error. In this respect, it is understood that those who played puzzle-entertainment games had lower error scores than those playing other game types. No significant difference was found in terms of the other parameters.

Discussion

Many studies have been conducted in recent decades on the benefits and harms of digital games. While a consensus has been reached regarding the benefits and harms on some issues, there are still ongoing serious debates on certain issues. The related discussions are increasingly growing as especially digital games vary widely according to their types and contents. One of these is the contribution of digital games, which is the subject of this research, to cognitive skills and functions. In the literature, general comparisons have been made in terms of those who play digital games and those who do not, and cognitive issues have been examined with respect to game types and even specifically in terms of certain games and tasks in the game. In this study, the individuals who played digital games and those who did not were compared depending on their scores on the neuropsychological tests of Wisconsin Card Sorting Test, Öktem Verbal Memory Processes Test and Digit Span Test. Moreover, neuropsychological test scores were examined with respect to the game type.

In this study, first of all, regardless of the game type, no significant difference was found in the overall neuropsychological test scores (all the sub-parameters) of those who played digital games and those did not. When the comparisons were examined in terms of game types, no significant findings were obtained. Strikingly, the findings were not generally consistent with those obtained in many other studies in the literature. In this study, three different neuropsychological tests were used, and these tests aimed to measure cognitive functions such as abstraction, conceptualization, mental flexibility, problem solving, immediate memory, learning and retention, recall, simple and complex attention, and working memory. According to the findings obtained in this study, these cognitive functions did not show a significant difference between those who played digital games and those who did not. However, there were consistent results in the literature with those obtained in the present study;[16] mostly, the contributions of digital games (including action-war games) to cognitive skills and processes were revealed in many studies.[5-7,12-15] Undoubtedly, there may be many reasons for these different findings. In some studies, collecting data using a single specific game or specific tasks may also lead to different findings. In addition, various factors like academic achievement, daily game playing time and participation in social activities other than age, culture, method, and measurement tools used[23-27] may help obtain different findings regarding the effect of games on cognitive functions. Although this study generally included a sufficient number of participants who played games and who did not, there were not enough participants for each game type in terms of examining the game types with parametric analysis; therefore, non-parametric test was used for the analysis regarding the game type. This was a limitation of the present study. In future studies, more participants playing each type of game could be included, and these neurological tests could be conducted again.

The participants in the study were users who had been playing games for at least the last six months. However, daily usage hours of each user could not be measured in detail. The reason for this was the fact that many participants played games every other day or did not play games regularly every day. For this reason, data were collected in relation to the weekly game playing times of the participants. Admittedly, this did not provide detailed data, and this might have caused differences in the findings obtained in the study. In this respect, as another limitation of this study, a detailed duration of use was not included in the analysis, and other factors likely to affect cognitive functions were not examined. In future studies, research data on more factors related to digital games could be collected, and relevant factors other than digital games could be included in the analysis. Participants playing games every day and for more than a few hours may provide more data to reveal the effect of digital games on cognitive scores. However, at this point, a study conducted in the literature invalidates this prediction. According to a study conducted by Boot and colleagues,[16] expert video game players did not have any difference in terms of cognitive performance compared to non-players. The fact that there was no significant difference in the cognitive scores between the gamers/non-gamers and game types in this study was valuable for triggering new discussions in the literature and for revealing the relevant variables in the background.

It would be more useful to continue this discussion, especially within the context of digital action games, because educational or serious digital games do not include inappropriate elements in terms of content. In this respect, as educational or serious games do not have an addictive feature, evaluating the benefit-harm balance only in terms of the duration of use will be sufficient to provide the necessary benefits at the optimum level. On the other hand, digital action games contain both addictive elements and inappropriate elements such as blood, weapons, sexuality, violence and slang language. The issue that needs to be discussed at this point is that some studies in the literature argue that action games provide cognitive benefits. In the literature, it has been shown that action games contribute to cognitive and visual selective attention and visual short-term memory.[16,20-22] In addition, it was revealed that action games had some benefits and contributions to cognitive processes or executive functions.[5-7,9,13-15,21] However, even though some contributions of action-war games to cognitive functions were revealed, which was not found in this study, it was a matter of debate whether these contributions had long-term effects or not. On the other hand, the few and relative benefits and contributions of these games should be approached with caution, considering the addiction and all other negativities that these games will develop. Another point is that it would not be healthy to evaluate every action game cognitively without categorizing it in terms of content. A limitation of this study is that the cognitive scores of action games were examined without evaluating their content. Another limitation of this study was that the cognitive scores regarding action games were examined without evaluating their content. However, there is also an opinion in the literature that some action games can appeal to much more cognitive abilities and include related cognitive tasks.[40]

The contributions of digital games to executive functions related to cognitive processes such as immediate memory, maintaining attention, planning, organization, self-control, and cognitive flexibility are limited only to some digital games and game contents. In addition, the features of digital games that can be used for learning and cognitive skill training[41] should be clarified better, taking into account the benefit-harm balance of digital games.

Conclusion

Although more detailed data about digital game playing time and game type were not obtained in this study, the large number of participants and the fact that the data on cognitive functions and performances were collected through three different neuropsychological tests make this study important for the literature. However, in contrast with many studies in the literature, this study found no significant difference in cognitive functions and performances between those who played digital games and those who did not or between the game types. Conflicting research findings in this context necessitate further investigation of this issue.

"This research was produced from the master's thesis of the first author."

Declarations

Ethics approval:

This study was carried out in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Izmir Bakircay University (08.12.2021 / Decision No: 422 / Research No: 402).

Consent to participate:

Informed consent was obtained from all individual participants included in the study.

Consent to publish:

Participants signed informed consent regarding publishing their data.

Funding:

There was no Funding

Contribution:

Authors contributed to the manuscript equally

Competing Interests:

There are no Competing Interests

Data Availability:

Data are available on request only due to ethical reason.

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