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ORIGINAL RESEARCH

The relationships between video game experience and cognitive abilities in adolescents

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Objectives: Video games are especially popular among adolescents and young adults as a form of entertainment and the amount of time spent playing video games has increased rapidly. The main objective of this study is to assess the effect of video games on cognitive functions in adolescents.

Methods: An exploratory, cross-sectional study was employed to investigate cognitive function in adolescent video game players. Cognitive functions, including memory, attention, and executive functions, were evaluated in 46 adolescents who had been playing video games regularly for at least 1 h per day, 5 days per week, for at least a year, and 31 adolescents (who played video games <5 h per week) using cognitive function assessment tests. Other data, such as demographics, medical information, video game types, and time spent playing video games were collected by questionnaires.

Results: No significant difference was detected between the groups in terms of age, gender, IQ levels, and sociodemographic variables. Our findings show that visual memory results were slightly better in the playing group. Moreover, in the group that plays video games regularly, the increase in daily time spent playing games significantly increased the total error value in the Stroop Test and total interference value in California Verbal Learning Test-Children's Version test. We also found that more time is spent on online games compared with traditional games.

Conclusions: In this study, we emphasize the pathological and uncontrolled consumption of video games and the possible consequences of time spent playing games. Our findings indicate the need for more extensive research. Future research should address the various implications of video game play, especially between the potentially positive and negative effects of video games.

Keywords: video games, cognitive functions, school children, adolescents

Introduction

In the last decades, the playing of video games has become one of the most popular forms of entertainment worldwide. Among users, adolescents and young adults are the greatest consumers of video games. Adolescents consume a form of entertainment media, such as TV, the Internet, computer, and video games, for about 9 h every day.[1] Research by the Entertainment Software Association in 2015 reported that there is at least one person that regularly plays video games 3 times or more in a week in 63% of American households and about 26% of the players were 18 years of age or younger.[2] Technological advancements, urbanization, and insufficient playground areas are the main reasons traditional game activities are changing towards digital games. In the traditional videogames, regardless of their type,

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a sole participant plays against the machine. However, driven by the spread of the internet, interest in online games has increased steadily. Currently, online video games have become the most popular type played worldwide. Therefore, video game playing hours by day have increased rapidly.[3] Nielsen reports that total weekly time spent playing games increased from 5.1 h in 2011 to 6.3 h in 2013.[4] With growing video game development and use, there are concerns regarding potentially problematic gaming behaviors. The type of video game played might influence the likelihood of developing behaviors. Several studies have documented that some adolescents or young adults present symptoms of problematic video game use, which are similar to other well-described addictive disorders. This situation is most evident for online games.[5]

The increasing prevalence of digital media has led to growing public concerns about potential detrimental effects, including the possibility that video games might be addictive. Although there are some studies that research the effect of video games on cognitive functions and academic performance in children, it is still a popular subject of debate. Yet little is known about the neural mechanisms that mediate such cognitive benefits. The results of those studies on that subject are different in almost every study.[6] Even though there are some studies that show a positive effect on cognitive functions with playing video games, there are also multiple studies that show no significant difference between players and non-players.[7–9]

Children are in a vulnerable stage of development, with many modulating factors. Also, many cognitive abilities are not fully developed in this age group. This is because the brain, especially the prefrontal cortex, has not fully developed at this age stage. Longitudinal studies show that gray matter volume increases in early childhood and then declines after puberty.[10] A decline in gray matter volume is prominent between adulthood and old age.[11] There are many studies that could show that the use of video games is an effective cognitive training or neuropsychological rehabilitation method, which could be used to improve hippocampal plasticity and to reduce age-related cognitive limitations.[12,13]

In recent years, there has been increasing interest in the possible effects of video gaming on various cognitive functions. Cognitive load is an important consideration, particularly in children. The main objective of this study is to assess the effect of video games on cognitive functions and visual and auditory performance in chronic (at least 1 h in a day, 5 days in a week, for a year) video game players between 10 and 16 years old. Thus, this study aims to: i) compare cognitive functions between video game players and non-video game players; and ii) investigate the association between time spent on video gaming and cognitive functions. This study does not formally assess gaming addiction, and therefore heavy gamers may or may not have problems associated with excessive gaming. The heavy gamers in the study simply imply those who play for 4 h or more each day.

Methods

The study was designed as a cross-sectional trial. As per the Declaration of Helsinki (1991), written informed consent was obtained from each study subject and their parents. Approval for the study was obtained from the local Ethics Committee (University of Health Sciences, Dr. Lütfi Kırdar Kartal Training and Research Hospital, Approval number: 2017/514/104/1). The subject group of this study is composed of volunteer healthy Turkish schoolchildren between 10 and 16 years old, without any prior cognitive function impairment or chronic disease. Participants who reported that they had regularly played a video game for at least 1 h per day, 5 days per week, for at least 1 year were included in the study. A self-report multiple choice questionnaire, which has five options (1, none or less than 1 hr; 2, 1–2 h; 3, 2–3 h; 4, 3–4 h; 5, ≥4 h) has been prepared to analyze the duration of video game play during weekdays and implemented as pre-experiment. Also, the type of video game or the name of the game they were playing was asked in the questionnaire. In case there was no a consensus among the researchers in the classification of these types of games, the types of games were classified in five subgroups according to the responses [MMORPG/Online Role Playing Games (eg, World of Warcraft, League of Legends, Knight Online); Online First-Person Shooter (eg, Call of Duty, Battlefield); Real-time Strategy Games (eg, Age of Empires, Clash of Clans); Action/Adventure Games (eg, Uncharted, The Last of Us); and Survival/Platformer Games (eg, Sonic the Hedgehog, Rayman Legends)].

The participants were chosen from volunteers following an intake interview with the consent of their parents. We measured the intelligence quotient using the Turkish version of Wechsler Intelligence Scale-Revised Form (WISC-R). The WISC-R was used for IQ assessment and subjects with participants total IQ scores of 80 and above were included in the study.[14] Face-to-face interviews were been done with the parents of the participants. In addition to the prior history of cognitive impairment and chronic disease information, video gaming habits of participants were questioned. Before the study, a pediatric psychiatrist conducted a half-structured interview based on DSM-V criteria to exclude possible conditions that might affect neuropsychological test performance, such as attention deficit hyperactivity disorder, learning disability, tic disorders, autism, and mental retardation. Out of 236 possible subjects who consented to be included in the study during intake interview, 52 healthy children who play video games regularly were included in the study and consented to have tests done on them about their cognitive functions. During the study course, six subjects voluntarily left, and the study was successfully finished with 46 children that completed all tests. Thirty-one healthy children with total IQ levels of 80 and above who play video games less than 5 h per week were included in the study as controls following intake interviews. Figure 1 shows the study protocols.

Tests used in cognitive function assessment

Wechsler Intelligence for Children-Revised (WISC-R) is a commonly used intelligence test for assessment of intellectual level in children. Originally done by Wechsler in 1949, the test was reassessed and revised in 1974.[14]

Verbal Fluency Test (The FAS Verbal Fluency) is a measure of phonemic word fluency, which is a type of verbal fluency. Verbal fluency can be assessed by semantic and letter/phonemic paradigms in which the most commonly used letters are F-A-S within a prescribed time frame, usually 1 min. Number of words as well as perseverance are used in the assessment of results.[15]

Trail Making Tests A-B (TMT A-B) measures attention to speed, motor speed, visual screening, mental flexibility, perseverance, interference affinity, and reaction inhibition. It consists of two parts in which the subject is instructed to connect a set of 25 dots as quickly as possible while still maintaining accuracy.[16] Part A measures the processing speed based on visual screening ability, whereas Part B assesses the ability to change the setup between stimulation sets and following consecutive directions.

The California Verbal Learning Test-Children's Version (CVLT-C) provides clinicians with a method of assessing various aspects of children's verbal memory and is sensitive to memory deficits resulting from a variety of neurological conditions. CVLT-C is a widely used neuropsychological test that is used in the assessment of verbal learning and memory. Free and cued immediate, short-delay, and long-delay recall, recognition, learning, and forgetting rates, organization, serial position effects, interference, and error types are all reviewed in this word-list learning test. CVLT allows the clinicians to evaluate a large number of cognitive, verbal memory aspects as opposed to other verbal memory tests.[17]

Benton Visual Retention Test (BVRT) is used for the evaluation of visual perception, visual memory, and constructive visual abilities in subjects aged 8 years and above. It is used to determine the attention, cognition,

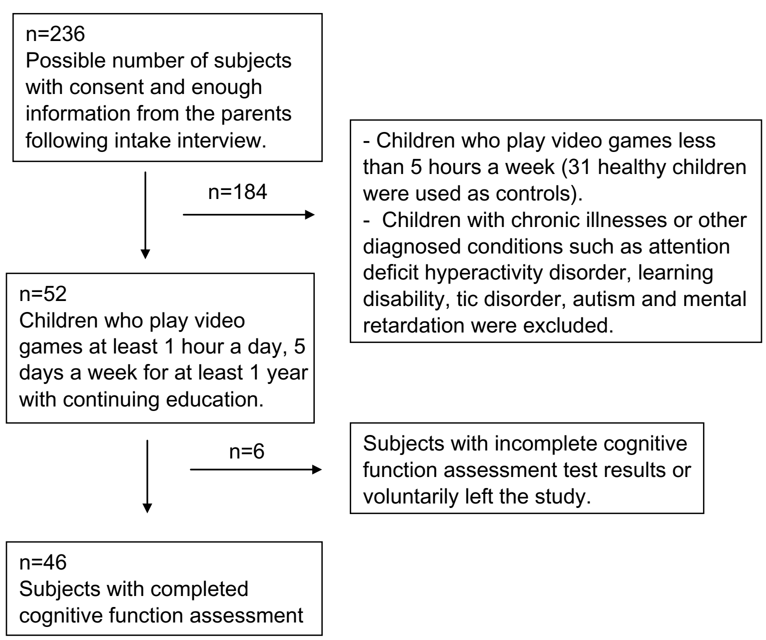

Figure 1 Flowchart of the study selection process.

and detection abilities in children, as well as to which memory the visual cues were recorded and the recall period.[18]

The original Stroop test and all current variations consist of three conditions: a word task, a color task, and a color-word task. The Stroop test is closely related to frontal love and other brain regions. The test gives information about cognitive processes, such as selective attention, focused attention, response inhibition, interference control, and information processing speed.[19] In the study, total error score and part completion period scores were used to determine selective attention, reaction inhibition, and interference control.

Statistical analysis

Statistical analysis of study results was done using Statistical Package for Social Sciences (SPSS) for Windows Version 22.0 software. Numerical variables were expressed as mean, standard deviation, and medians whereas categorical variables were shown as numbers and percentages. The Kolmogorov-Smirnov Test was used for variable distribution assessment. Categorical variables were analyzed using ANOVA, Kruskal-Wallis, and Mann-Whitney U Tests. The Chi-square test was used to compare the differences in categorical variables between the groups. The relationships between numerical variables were assessed using the Pearson or Spearman Correlation Coefficient. Correlation evaluation in other cognitive function assessment test results was done using partial correlation analysis with IQ and age variables under control. Significance level (p) was set as <0.05.

Results

In our study, we compared 46 children who play video games regularly with 31 healthy children who do not regularly play video games as controls. The mean age of the study group, which plays video games regularly, was 12.6±1.8, and 91.3% were males. The mean age of the control group was 12.4±2.1, and 90.3% were males. The mean video game playing period of video game player study group was 2.72±1.85 years. No significant difference was detected between the groups in terms of age, gender, IQ levels, and sociodemographic variables (Table 1).

In all groups, cognitive function assessment test results and their relationship between IQ, age, and each other was reviewed. According to these results; IQ and age had a significant relationship with time and number of errors in TMT-B, with total time and visual memory in CVLT-C and with time and number of errors in the Stroop test. Age and IQ were also used when comparing test results between study and control groups. No significant correlation was found between age and IQ with verbal fluency and CVLT-C long-term delayed recall (Table 2).

When comparing the tests that are found to have a significant relationship with age and IQ between the groups, a single-direction variance analysis was used to compare test scores between those groups. The effect of age and IQ levels were also taken into consideration.

Compared to controls, the regular video game playing group made more errors in the TMT-B, and Stroop tests and total recall scores were significantly lower in the CVLT-C, with a smaller number of recalled objects. As can be seen in Table 3, our findings show that visual memory results were slightly better in the playing group. Moreover, in the group that plays video games regularly, the increase in daily time

Table 1 Sociodemographic variables

	Study Group (n=46)	Control Group (n=31)	*p*
Age (m ± sd)	12.6±1.8	12.4±2.1	0.22
Male, n (%)	42 (91.3)	28 (90.3)	0.09
Maternal age (m ± sd)	39.6±5.6	37.8±5.1	0.21
Paternal age (m ± sd)	44.4±8.0	43.1±5.7	0.41
Parental marital status, n (%)			
Together	40 (86.9)	28 (90.3)	0.86
Maternal education, n (%)			
Primary school	20 (43.5)	16 (51.6)	0.74
Junior High School	6 (13.0)	4 (12.9)	
High school	16 (34.8)	6 (19.4)	
University	4 (8.7)	5 (16.1)	
Mother employment status, n (%)			
Employed	18 (39.1)	9 (29.0)	0.68
Unemployed	28 (60.9)	22 (71.0)	
Paternal education, n (%)			
Illiterate	0 (0)	2 (6.5)	0.67
Primary school	16 (34.8)	8 (25.8)	
Junior High School	10 (21.7)	5 (16.1)	
High school	14 (30.4)	12 (38.7)	
University	6 (13.0)	4 (12.9)	
Father employment status, n (%)			
Employed	46 (100)	31 (100)	
IQ (m ± sd)	106.1±17.8	100.7±12.8	0.074

Table 2 Correlation of tests with IQ, age and each other

	IQ	Verbal Fluency	Trail Making Test-B	CVLT-C Total Score	CVLT-C Long Recall	BVRT	Stroop Total Errors	Stroop Time Completion	Age
IQ	1								
Verbal Fluency	−0.114	1							
Trail Making Test -B	−0.464**	−0.109	1						
CVLT-C Total Score	0.256*	−0.216	−0.058	1					
CVLT-C Long Recall	0.099	−0.035	0.060	0.719**	1				
BVRT	0.464**	0.350**	−0.592**	0.228*	0.225	1			
Stroop Total Errors	−0.292**	−0.109	0.392**	−0.209	−0.240*	−0.363**	1		
Stroop Time Completion	−0.456**	−0.304*	0.448**	−0.347**	−0.339**	−0.604**	0.620**	1	
Age	0.178	0.013	−0.321**	0.462**	0.417**	0.595**	−0.431**	−0.542**	1

Notes: **p*<0.05; ***p*<0.01.
Abbreviations: IQ, Intelligence Quotient; CVLT-C, California Verbal Learning Test-Children's Version; BVRT, Benton Visual Retention Test.

Table 3 Comparison of tests that were found to be affected by IQ and age between groups

	Study Group (m ± sd)	Control Group (m ± sd)	f	p
CVLT-C Total Score[a]	44.73±8.39	47.96±7.42	8.137	0.008**
CVLT-C Long Recall[b]	9.57±2.97	10.22±2.54	2.819	0.114
Trail Making Test –B Time Completion[a]	122.58±51.22	138.85±88.14	5.030	0.044*
Trail Making Test –B Total Errors[a]	1.85±2.46	1.36±1.72	7.871	0.009**
Stroop Time Completion[a]	103.68±30.55	114.99±31.34	1.294	0.089
Stroop Total Errors[a]	3.86±3.83	2.90±2.98	6.610	0.022*
BVRT-Total Score[a]	9.26±2.78	7.68±2.96	1.768	0.041*

Notes: **p*<0.05; ***p*<0.01; [a]Adjusted for IQ and age; [b]Adjusted for age.
Abbreviations: CVLT-C, California Verbal Learning Test-Children's Version; BVRT, Benton Visual Retention Test.

spent playing games significantly increased the total error value in the Stroop Test and total interference value in the CVLT-C test (Table 4).

According to classification done by game type, we have detected that out of 46 participants, 36.96% (n=17) were playing MMORPG/Online Role Playing Games, 30.44% (n=14) playing Online First-Person Shooter, 19.57% (n=9) playing Real-time Strategy Games, 8.70% (n=4) playing Action Adventure, and 4.35% (n=2) playing Survival/ Platformer games. Interestingly, we found that those who prefer online games spend more time on platforms.

Those participants who expressed that they play more than 4 h per day were the seven individuals playing "MMORPG/Online Role-Playing Games", and five individual playing "Online First-Person Shooters". Besides, the individuals playing these two game forms accounted for more than half of the participant population (Figure 2). When cognitive functions were analyzed regarding preferred game types, we observed that while "Online First Person Shooter" players made more mistakes than the others in the TMT-B test, the visual memory test and Stroop total time was better in the 'Real Time Strategy players group (Table 5).

Discussion

Video games have become a popular activity among adolescents and young adults. The increased number of digital games, which are also supported with virtual environments, online platforms that allow being a member of teams with different cultures and countries, now make it necessary to investigate the negative impact of gaming on children. The constantly growing scientific literature on this subject is mainly focused on the short- and long-term effects of digital games. Researchers use different terminologies to describe game addiction. This

Table 4 Correlation of test results that were found to be significantly affected by age and IQ with hours spent playing video games in a day

	Control Group (m ± sd) (n=31)	Study Group (m ± sd)			
		1–2 h (n=9)	2–3 h (n=14)	3–4 h (n=10)	≥4 h (n=13)
Trail Making Test –B Time Completion[a]	138.85±88.14	132.28 ±71.47	126.64±50.82	124.55±51.20	117.78 ±46.22*
Trail Making Test –B Total Errors[a]	1.36±1.72	1.48±2.06	1.75±2.29*	1.92±2.12**	2.26±1.98**
CVLT-C Total Score[a]	47.96±7.42	48.23±9.12	45.96±8.68*	41.73±8.34**	40.72±9.22**
CVLT-C Long Recall[b]	10.22±2.54	10.17±3.87	9.48±2.90	9.67±2.79	8.92±3.07*
Stroop Total Errors[a]	2.90±2.98	3.16±2.83	3.46±3.24	3.98±3.96	4.06±3.88*
Stroop Time Completion[a]	114.99±31.34	115.68 ±40.12	103.68±35.62	96.68±30.50*	99.68±39.05*
BVRT[a]	7.88±2.93	8.06±1.72	9.16±2.05*	9.77±3.68*	9.46±2.18*

Notes: *$p<0.05$; **$p<0.01$; [a]Adjusted for IQ and age; [b]Adjusted for age.
Abbreviations: CVLT-C, California Verbal Learning Test-Children's Version; BVRT, Benton Visual Retention Test.

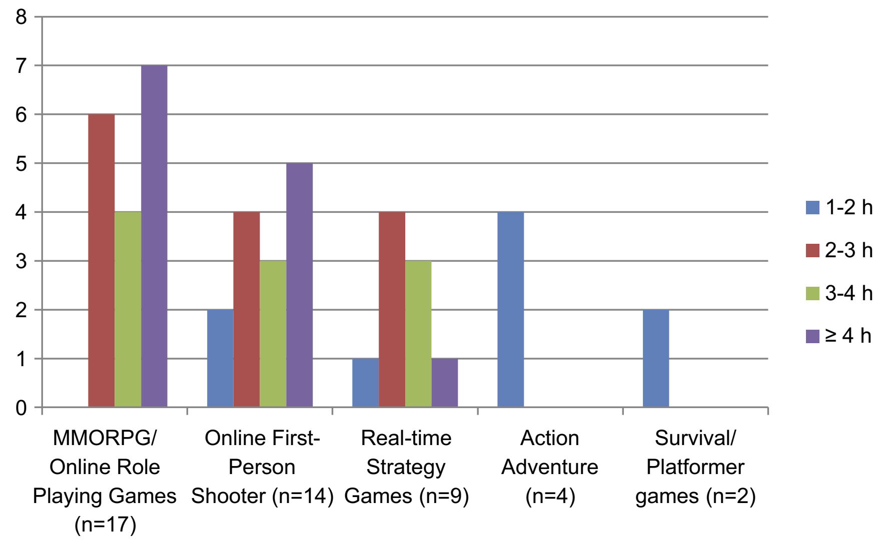

Figure 2 The amount of time spent per day on video game types.

concept is reported as "overuse of games", "obsessive-compulsive game playing", "gaming addiction", "pathological gaming behavior", and "problematic game playing behaviors".[20,21] However, clinicians refrain from using the term "game addiction". The American Psychiatry Association (APA) has recommended more studies to be done on this subject, which support a clinical diagnosis as well as a definition of mental disease to be added to their handbook.[22] In our study, we preferred not to use those terms. Here we have examined the effect of regularly and continuously playing video games on cognitive functions.

Indeed, several clinicians and empirical studies have reported the beneficial effects of video game experience; however, the effects presented age-specific and task-specific characteristics. The age-related and task-related effects of videogame experience across the adult life span are still unknown.[23] The study strength was increased as there were no significant differences in terms of age, gender, socioeconomic status, and IQ levels between the groups and we excluded children and adolescents with a history of conditions, which might affect cognitive functions, such as attention deficit hyperactivity disorder and dyslexia. As with previous studies, in our study the majority of game players were males. The study results show that male teenagers aged between 10 and 19 were more likely to overplay video games and develop a problematic usage of games compared to female teenagers and other age groups.[20,21]

Table 5 Correlation of test results that were found to be significantly affected by age and IQ with video games types

	Control Group (n=31)	MMORPG/Online Role Playing Games (n=17)	Online First-Person Shooter (n=14)	Real-time Strategy Games (n=9)	Action Adventure (n=4)	Survival/ Platformer games (n=2)
TMT-B Time Completion[a]	138.85±88.14	122.28±66.41	128.64±53.12	130.55±41.47	137.18±36.20	140.78±34.05
TMT-B Total Errors[a]	1.36±1.72	1.66±2.86	1.85±2.91*	1.40±1.12	1.38±1.77	1.76±0.90
CVLT-C Total Score[a]	47.96±7.42	44.93±9.12	45.06±8.68	48.73±8.34	49.72±8.42	41.72±6.22
CVLT-C Long Recall[b]	10.22±2.54	9.07±4.81	9.98±2.90	11.67±3.45	8.92±3.07	10.92±2.89
Stroop Total Errors[a]	2.90±2.98	3.16±2.83	3.43±3.84	2.37±1.96	2.06±1.88	3.01±2.08
Stroop Time Completion[a]	114.99±31.34	105.68±40.12	113.68±22.81	95.68±18.50*	116.68±10.05	98.68±10.05
BVRT[a]	7.88±2.93	9.06±2.02	8.16±2.05	9.86±3.68*	8.06±2.98	7.46±1.18

Notes: *$p<0.05$; **$p<0.01$; [a]Adjusted for IQ and age; [b]Adjusted for age.
Abbreviations: CVLT-C, California Verbal Learning Test-Children's Version; BVRT, Benton Visual Retention Test; TMT-B, Trail Making Tests A-B; MMORPG, Massively Multiplayer Online Role Playing Game.

When the tests used to assess cognitive functions are reviewed, it can be seen that their results contradict each other. Some of the studies argued that video games have positive effects on memory or attention.[24,25] However, there are also studies that do not support this argument.[26,27] After the review of previous studies, we decided to assess the tests with significant correlations between each other together as opposed to comparing each test individually. The first aim of this study was to compare cognitive functions between video game players and non-videogame players. In this study, when the tests were compared, it was seen that IQ and age had a significant correlation with almost all tests, except verbal fluency and CVLT-C long-delayed recall. The analysis based on this correlation showed that the group that plays video games regularly made significantly higher errors in TMT-B and Stroop tests and remembered fewer objects in CVLT-C test total recall scores when compared to controls that do not regularly play video games. Although some studies argue that video game playing improves some abilities, such as selective attention and speed, other studies have proposed that video games cause an indirect decline in those abilities by promoting a sedentary lifestyle.[28] Another purpose of this study was the curiosity of the relation between cognitive functions and the time spent on video gaming. Based on our test results; we concluded that the difference between the two participant groups was directly related to the time spent on video games and that those with heavy video play made a significant error in these tests. It was remarkable that their TMT-B and Stroop test completing duration was shorter in the gamer group; however error rates were higher. Moreover, the gamer group performed better in visual memory test.

Action games were among the first to be studied, and so far have dominated the literature. Traditional games have become online over time and this made them more appealing among gamers. Green and Bavelier discovered that action video game players perform better than novices in a series of visual attention tasks. Furthermore, non-game players trained to play action video games have been shown to improve on untrained tasks of visuospatial attention.[29,30] Our results also confirm the findings of Green and Bavelier, who conclude gamers' visual attention performance was better. But we could not obtain better performance in Stroop and TMT-B tests in our study groups. This situation may be related to the time spent for the game has been formed.

An important contribution with this study is the finding that the total recall scores of our subject group (children who regularly play videogames) are significantly lower than those of the control group (children who do not regularly play video games). Furthermore, increased game playing hours was related to a significant increase in total error/interference score in CVLT-C and TMT-B and Stroop tests. A study by Tahiroglu et al reported that time spent playing video games might have a short-term effect on attention measured by the Stroop test.[31]

All games are not composed equally. There are many different types of games, each utilizing a variety of mechanics. For example, strategy games have been associated with better problem-solving skills and higher grades in adolescents. We found that players of real-time strategy games have faster reaction times than FPS players.[32] Another study has claimed that experienced real-time strategy players perform better than young adults and elders in higher-order cognitive skills.[33] Interestingly, in many studies, it was found that older adults exhibit significant deficiencies in higher cognitive skills compared to young adults.[34]

Very few studies have attempted to explore the differences between various types of video games. Much more work is therefore needed in this area, especially if games are to be understood as a tool for cognitive intervention strategies. Studies indicate that the increase of hours in spending playing video games can increase the risk of developing problematic play behaviors of individuals.[35] In this study, we found that people who play video games heavily are those who mostly play online and prefer MMORPG and FPS games. The psychological aspects of MMORPG have been studied from various perspectives. Thus, these players are at the risks of addiction to the game and of consumption of alcohol and drugs.[36,37] One study reported a lower Stroop effect in subjects with non-/low-frequency game use or recreational (non-problematic) game use compared to subjects with internet gaming disorder. Also, the same study reported that subjects with recreational (non-problematic) game use showed more activity in brain regions as opposed to subjects with internet gaming disorders.[38] On the other hand, some studies also reported a disturbance in cognitive control ability in adolescents by performing the color-word Stroop task on subjects with online gaming addiction.[39] Our study also showed similar results, and we saw that the video game play group made more errors in Stroop tests compared to control groups.

It is known that adults and young people process information differently and this situation affects the performance of various cognitive tasks.[40] It is now well-accepted that video games affect cognitive functions and learning in a positive way. However, we are not able to put into medical practise this positive effect completely yet. We believe that, in the future, custom-designed video games can serve as a powerful tool for assessing cognitive abilities across the lifespan, evaluating underlying neural mechanisms and cognitive enhancement. Primarily, long-term, cross-sectional and controlled studies investigating the potential effects of video games are needed. In this study, we emphasize the pathological and uncontrolled consumption of video games and the possible consequences of time spent playing games.

Study limitations

This study has several limitations. First, the normative sample was a cross-sectional one. Because of the cross-sectional nature, it is impossible to determine the direction of the associations between the data. Longitudinal studies will be needed to rule out possible cohort effects. Participant's responses toward the interview questions have been presumed sincere and candid, but self-report is open to many well-known biases, such as social desirability and memory recall biases, that may impact the veracity of the findings.

Moreover, the reported time playing games (as the intake interviews) were done with parents, and there might be a discrepancy between the times reported playing games by parents and the child; with parents possibly reporting less. Another salient limitation of the current study is our lack of consideration regarding the participant's previous video game experience. Video games vary greatly from genre to genre, both in terms of form and context. Thus, the cognitive skills identified in our study might not be relevant to other genres of gaming. There is also a need to replicate these results in larger groups of gamers, especially online gamers. Thus, some of the results could be due to the sample size. It is possible that some differences (or lack of differences) are artificial (because of the sample size). For this reason, our results need to be confirmed by studying larger samples. Despite these limitations, this study can provide new insights and open up new research approaches.

Conclusions

In conclusion, our findings indicate the need for more extensive research. Even though there are studies in the literature that mention the positive effects of video games; the necessity for research addressing the relationships between cognitive ability and gaming habits is obvious. Future studies could investigate more ranges of higher-order cognition, such as reasoning and everyday cognition, to differentiate between different types of video games. Such work would further our understanding of the relationships between cognition and video games.

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Author contributions

All authors contributed to data analysis, drafting or revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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