NESNE Psikoloji Dergisi

The Relationship Between Digital Game Addiction, Executive Functions and Impulsivity in Early Adolescents

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Keywords
Video game addiction, attention, impulse control, cognitive flexibility, early adolescence

Abstract

The current study was largely concerned with the association between digital game addiction, specific cognitive functions especially, three components of executive function (inhibition, set shifting and working memory) and impulsivity in early adolescents. Sampling consisted of 6th (55.1%) and 7th (44.9%) grade middle school students (36 females and 62 males). The mean age of the students was determined as 12.35 years (*SD* =0.75; age range, 10–14 years). Digital game addiction, inhibition, set shifting, working memory, and impulsivity were evaluated via Digital Game Addiction Scale (DGAS), Stroop Test TBAG Form, Trail Making Test (TMT), Wechsler Memory Scale-III Letter-Number Sequencing Subtest (WMS–III/LNS) and Short Form of Barratt Impulsiveness Scale (BIS-11-SF), respectively. According to the correlation analysis results, selective and complex attention, inhibition, set shifting, and impulse control were diminished with increasing digital game addiction. There is no significant relationship between digital game addiction and working memory. Consistent with the correlation analysis, structural equation model results revealed that digital game addiction significantly predicts inhibition, set shifting and impulsivity [x^2 (15, N = 98) = 7.476, $p > 0.5$; x^2/df = 1.246; RMSEA = .05; CFI = .95; GFI = .97]. As a results, it can be concluded that digital game addiction should be controlled in order to manage impulses and develop high-capacity cognitive skills in children.

Erken Ergenlerde Dijital Oyun Bağımlılığı, Yürütücü İşlevler ve Dürtüsellik Arasındaki İlişki

Anahtar kelimeler
Video oyun bağımlılığı, dikkat, dürtü kontrolü, bilişsel esneklik, erken ergenlik

Öz

Bu çalışmanın amacı, erken ergenlerde dijital oyun bağımlılığı, yürütücü işlevlerin üç bileşeni (set değiştirme/zihinsel esneklik, ketleme ve çalışma belleği) ve dürtüsellik arasındaki ilişkiyi incelemektir. Araştırmanın örneklemini 6. (%55,1) ve 7. (%44,9) sınıf ortaokul öğrencileri (36 kız, 62 erkek) oluşturmuştur. Öğrencilerin yaş ortalaması 12,35 (*SS* = .75; yaş aralığı, 10-14) olarak belirlenmiştir. Dijital oyun bağımlılığı, inhibisyon, kurulumu değiştirme, çalışma belleği ve dürtüsellik sırasıyla Dijital Oyun Bağımlılığı Ölçeği, Stroop Testi TBAG Formu, İz Sürme Testi, Wechsler Bellek Ölçeği-III Harf-Sayı Sıralama Alt Testi ve Barratt Dürtüsellik Ölçeğinin Kısa Formu ile ölçülmüştür. Korelasyon analizi sonuçlarına göre, dijital oyun bağımlılığı arttıkça seçici ve karmaşık dikkat, inhibisyon, kurulumu değiştirme ve dürtü kontrolü azalmaktadır. Dijital oyun bağımlılığı ile çalışma belleği arasında anlamlı bir ilişki bulunmamıştır. Korelasyon analizi sonuçlarıyla tutarlı olarak yapısal eşitlik modeli sonuçları da, dijital oyun bağımlılığının inhibisyon, kurulumu değiştirme ve dürtüselliği anlamlı olarak yordadığını göstermiştir [x^2 (15, N = 98) = 7.476, $p > 0.5$; x^2/df = 1.246; RMSEA = 0.050; CFI = 0.95; GFI = 0.97]. Sonuç olarak, çocuklarda dürtülerin kontrol edilmesi ve üst düzey bilişsel becerilerin geliştirilmesi için dijital oyun bağımlılığının kontrol altına alınması gerektiği söylenebilir.

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The technological advances have completely changed many aspects of individual's daily routines, as well as children's playing habits. Releasing of the first video game in 1973 brought about substantial changes in adults and children's leisure activities (Doğan, 2006). Digital games have become increasingly common in recent years, and over 1 billion people around the World play video games. Also, people have become acquainted with these games at an early age (Dinç, 2012).

In fact, the percentage of households with internet access was 94.1% in August 2022 in Turkey (TÜİK, 2022). Increased use of the internet in the 21st century has led people to the problematic use of video games. As a result, traditional games, which are of vital importance for the healthy development of children and adolescents, have been replaced by internet/video games. Therefore, it is important to understand the potentially negative effects of playing video games on academic success and mental health of children and adolescents (Akınoğlu, 2002; Kelleci, 2008).

It is thought that digital games can have significant effects on cognitive processes. In particular, it is known that controlled and conscious use of digital games is beneficial for children in some fields, such as visual intelligence and visual-spatial perception, hand-eye coordination and attention (Feng et al., 2007; Green & Bavelier, 2003; Subrahmanyam et al., 2000), while uncontrolled use of digital games can cause adverse effects (Chan & Rabinowitz, 2006; Christakis et al., 2004; Swing et al., 2010). Executive function skills including inhibition, cognitive flexibility, attention and sensory processing are considered as cornerstones of high-level cognitive processes (Staiano et al., 2012). Miyake et al. (2000) defined three basic executive functions: inhibition, shifting or mental flexibility and updating/monitoring or working memory. Inhibition refers to an ability to suppress or override inappropriate, automatic and dominant responses and maintain attention for appropriate response. Shifting includes the ability to switch between tasks or mental sets or a course of thought or action according to the changing demands. Updating is closely related to working memory and means a cognitive system with a limited capacity that is responsible for the temporary storage and manipulation of complex tasks. Working memory, which is characterized by short-term storage and processing of information, is considered an important component of executive functions (Miyake et al., 2000). Working memory provides the direction of thought or attention, problem solving and planning, and organizing a situation. It inhibits an inappropriate thought or behavior. It ensures that appropriate behaviors can be effectively sequenced and maintained. Therefore, working memory is a skill that has a huge impact on learning. (Cowan, 2014). There are contradictory results in the literature in terms of the relationship between digital gaming and three executive functions. For instance, Özçetin et al. (2019) suggested that Stroop Test performance (inhibition and selected attention task) had decreased with increasing in daily time spent playing games. In the literature, some studies generally linked digital game playing with greater attention deficits (Farchakh et al., 2020; Swing et al., 2010). On the one hands, other studies indicated that video game players have better attention competencies than non-video game players (Castel et al., 2005; Green & Bavelier, 2012). However, Farchakh et al. (2020) yielded that digital games have negative effects on working memory, Steenbergen et al. (2015) reported that individuals with active videogame-players have better working memory and cognitive flexibility than individuals with little to no videogame experience. On the other hand, Samson et al. (2021) found that children with regularly played video games performed better selective attention, but not working memory, and set shifting. Another work also demonstrated that working memory and cognitive flexibility performance of frequent internet gaming group did not differ from infrequent gaming group (Chen & Hsieh, 2018). Most research investigating the link between the video games and cognitive flexibility has showed contradictory findings. That is, while some of studies reported that there was no significant difference between video game players (Cain et al., 2012; Collins & Cox, 2012) and non-video game players in terms of cognitive flexibility performance, other studies revealed a video game players perform greater cognitive flexibility (Colzato et al., 2010; Karle et al., 2010). According to Dobrowolski et al. (2015) these different findings can stem from the heterogeneity of video game types.

The presence of impulsivity symptoms in individuals with addiction indicates that there may be disruptions in impulse control and inhibition which is an important component of executive functions (Dong et al., 2010). Particularly, some studies indicated that impulsivity is positively correlated with playing too many computer games (Cao & Su, 2007; Meerkerk et al., 2010). Moreover, Gentile (2009) indicated that video gaming addiction was associated with increased impulsivity level. In addition, it was claimed that video games were associated with reduced cognitive control (West et al., 2020). Consequently, it is expected that there will be problems in impulse control with increasing digital game addiction in adolescents.

When considered together, aforementioned studies indicate that there may be a relationship between digital game addiction and executive functions and impulsivity. However, both negative and positive associations reported between digital games and executive functions in the literature. The first aim of the present study was to find answers to the contradictory results regarding the direction of the relationship between digital game addiction and executive functions. Furthermore, to the best of our knowledge, there is no study that measures all the variables together in the literature. Specifically, through a holistic model, it can be clarified which executive function would have predicted by digital game addiction. Thus, the second aim of the study was to determine whether the digital game addiction predicts the level of function of the three executive functions (inhibition, shifting, working memory) and impulsivity in a model.

Method

Participants

Sampling consisted of Ninety-eight 6th (55.1%) and 7th (44.9%) and middle school students (36 females and 62 males) studying in located in the central districts of Bolu province in Turkey. Participants were determined according to the convenience sampling method. The mean age of the students was determined as 12.35 years (*SD* =.75; age range, 10–14 years). The details about the demographic variables of the students are demonstrated in Table 1.

Measurements

Demographic Information Form: This form was consituted to obtain information about the participants (e.g., gender, age, handedness of participants, and state of health [whether they have an illness (i.g., neurologic, psychiatric) or whether they have visual color separation problem], how long they have been playing video games). Participants reporting neurological or psychiatric disturbance stories were not included in the sample.

Digital Game Addiction Scale (DGAS): The DGAS (21 item-original form) was developed by Lemmens et al. (2009) to specify problematic digital game behavior among adolescents (aged 12-18 years). In this study, 7-item version of DGAS (short DGAS) adapted to Turkish by Yalçın et al. (2015) was used. The DGAS composed of 7 items scored on a 5-point Likert-type scale and is unidimensional. The internal consistency of the adapted Turkish DGAS was .72. In the present study, internal consistency value of DGAS was found as .79.

Table 1
Demographic Characteristics of Participants

Variable	*N* = 98	%
Gender		
Female	36	36.7
Male	62	63.3
Typical weekday video game playing (per day)		
0-30 min	25	25.5
31-60 min	25	25.5
1-2 hours	33	33.7
2-3 hours	7	7.1
3-4 hours	4	4.1
4-5 hours	1	1.0
More than 5 hours	3	3.1
Typical weekend video game playing (per day)		
0-30 min	10	10.2
31-60 min	13	13.3
1-2 hours	25	25.5
2-3 hours	23	23.5
3-4 hours	12	12.2
4-5 hours	7	7.1
More than 5 hours	8	8.2
	M	*SD*
Age	12.35	.75
How many months they have played video games	38.59	29.79
How many days a week they have played video games	3.9	2.03

Short Form of Barratt Impulsiveness Scale (BIS-11-SF): BIS-11-SF was developed by Spinella (2007) and adapted into Turkish by Tamam et al. (2013). This inventory includes 15 items with 4-point Likert type scale and 3 subscale [(Non Planning (NP), motor impulsivity (M), and attention impulsivity (A)]. Internal consistency coefficients were obtained for the total and NP, M and A subscales with scores of .82, .80, .70 and .64, respectively. In the current study, these values were found as .75, .71, .65, .63, respectively.

Stroop Test TBAG Form: The Stroop Test TBAG Version, which is important to assess focused attention, was developed by Stroop (1935) and adapted into Turkish by Karakaş (2006). The Stroop Test is also used as an executive function test measuring inhibition (Miyake et al., 2000). The test consists of 5 stimulus cards, but the stroop effect appears on the 5th card. In this card, participants encounter with a word written in a color and they should name the ink color ignoring the word itself. Total error number, total duration, and point of correct number scores are calculated for each card.

Trail Making Test (TMT): The TMT was developed by Reitan (1958) and adapted into Turkish by Türkeş et al. (2015). The test is administered in two parts (form): Part A and Part B. The participants are required to switch between the numbers (1-13) in ascending order and letters (A-I) in alphabetical order as quickly as possible in Part B. (i.e., 1-A-2-B-3-C). This part is generally used to evaluate complex attention, set shifting, cognitive control and inhibition executive functions. Since the time score was taken into account in the scoring of the test, the researcher recorded the responses time (RT) during the task. A high Trail Making Test score indicates poor performance.

Wechsler Memory Scale-III Letter-Number Sequencing Subtest (WMS–III/LNS): WMS-III Letter-Number Sequencing Subtest (Wechsler, 1997) was used to measure the capacity of the working memory. WMS–

III/LNS was adapted into Turkish by Ant (2005) and Özdemir (2005). In this test, the participants are read numbers and letters in a complex sequence (an increasing number of series from 1 to 8) and asked to remember the numbers in ascending order and the letters in alphabetical order. The test consists of 7 items and each item has 3 trials. In this working memory test, in which each correct answer corresponds to 1 point, the highest possible score is 21. The test is discontinued after failure on all 3 trials of an item.

Procedure

After necessary ethical committee and school permissions were taken, students were informed briefly about the study in the classes and voluntary participants who stated playing video games were individually tested in the school guidance counseling service rooms. Neuropsychological tests were administered with the balancing scheme and by the researchers. Each participant completed all tests in approximately 30 minutes.

Results

Correlation Analysis

In the initial part of results, the descriptive statistics of the all test scores were determined (Table 2). Then, Pearson Correlation Analyses were conducted to find out correlation coefficients for digital game addiction and other variables scores (Table 3). Digital game addiction was significantly positively correlated with three impulsivity scores and executive functions except for working memory. Digital Game Addiction Total Score was significantly positively associated with Stroop 5th Part Correct Score (r = .21, p < .05) and Trail Making Part B Score (r = .21, p < .05). Digital Game Addiction Total Score and Non Planning (r = .38, p < .01), Motor Impulsivity (r = .44, p < .01) and Attention Impulsivity (r = .43, p < .01) were significantly positively correlated.

Table 2
Descriptive Statistics of the Test Scores

	N	*M*	*SD*	*Ranj*	*Skewness*	*Kurtosis*
Digital Game Addiction Total Score	98	13.90	5.07	25	1.31	1.95
Stroop 5th Part Correct Score	98	1.22	1.21	6	1.24	2.1
Trail Making Part B Score	98	82.18	29.29	147	0.92	1.36
WMS–III/LNS Total Score	98	8.52	2.49	13	0.19	-0.21
Non Planning (NP)	98	9.88	2.93	15	0.69	0.48
Motor Impulsivity (M)	98	8.79	2.35	12	1.10	1.51
Attention Impulsivity (A)	98	8.58	2.17	10	0.65	0.25

Table 3
Pearson Correlation Coefficients Regarding Digital Game Addiction

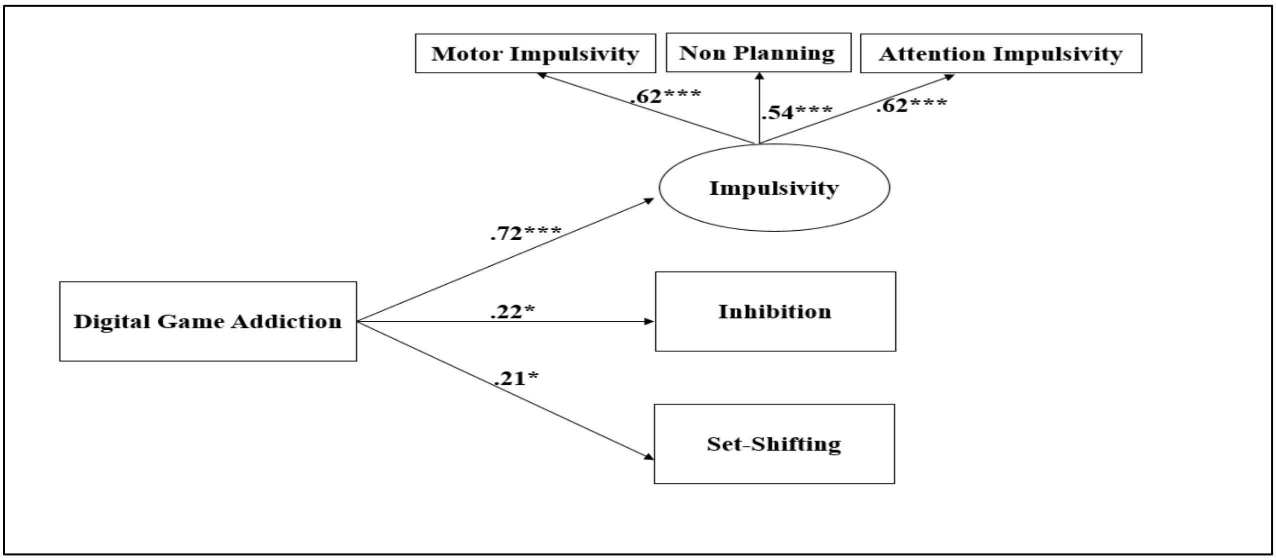
	Digital Game Addiction Total Score	Stroop 5th Part Correct Score	Trail Making Part B Score	WMS–III/LNS Total Score	Non Planning (NP)	Motor İmpulsivity (M),
Digital Game addiction Total Score	-					
Stroop 5th Part Correct Score	.21*	-				
Trail Making Part B Score	.21*	.20*	-			
WMS–III/LNS Total Score	.03	-.40**	-.22*	-		
Non Planning (NP)	.38**	.02	.13	.13	-	
Motor impulsivity (M)	.44**	.01	.01	.01	.33**	-
Attention impulsivity (A)	.43**	.22*	.09	.09	.43**	.54**

Significance of bold values are ***p** < .05, ****p** < .01, *****p** < .001

Structural Equation Model

The predictive effect of digital game addiction on inhibition and set shifting executive functions and impulsivity latent variable was tested with a structural equation model (SEM) conducted via the AMOS 23.0 program. In the scope of the current study, a set of fit indices were used depend on the literature. Thereby, when testing whether the hypothetical model has been confirmed, these parameters are taken into account: RMSEA < 10 (Brown, 2006); CFI ≥ .90 (Hu & Bentler, 1998); x2/df < 5 (Kline, 2005). Studies generally suggested that because some index values involving GFI, AGFI and NFI are sensitive to the parameter values and sample size in the model, they have produced biased values (Brown, 2006; Hu & Bentler, 1998; Kline, 2005). Thus, it is not considered necessary to use these values.

In the structural model, digital game addiction independent observed variable was obtained from Digital Game Addiction Scale total score. Impulsivity latent dependent variable was constituted by non-planning, motor impulsivity and attention impulsivity observed variables. Inhibition and set shifting observed dependent variables were formed by Stroop 5th part correct score and Trail Making Test total time score, respectively. Digital game addiction was significantly predicted impulsivity (β = .72, p < .001), inhibition (β = .22, p < .05) and set shifting (β = .21, p < .05). Thus, the results relatively revealed the compatibility of data to the sample: [x^2 (15, N = 98) = 7.476, p > 0.5; x2/df = 1.246; RMSEA = .05; CFI = .95].



***p* < .05, *****p* < .001.

Figure 1. Structural Equation Model (SEM) Regarding Digital Game Addiction.

Discussion

The aim of the present study was to examine the relationships among digital game addiction, impulsivity, and some cognitive processes. On the basis of the findings of the correlation analysis, digital game addiction score showed positive associations with Trail Making Test duration score and Stroop Test 5th part correct score. In line with this finding, it was observed that the performance of these tests, which measure complex, sustained and selective attention, decreased with increasing digital game addiction. The literature findings regarding "increased attention" problems due to digital games are supported by the present study (Farchakh et al., 2020; Swing et al., 2010). Our result may be understood that more time spent on video games may impair different types of attention. On the one hand, the current research results revealed that digital game addiction was not associated with working memory. In the literature, it is stated that adolescents with internet gaming disorder (Kuss et al., 2018) and spending too much time playing the same type of games (Farchakh et al., 2020) could have worse working memory capability. The sample of the current study consists of adolescents who have been playing video games for an average of one year. The current research finding, inconsistent with the literature may be due to the fact that the sample of the current research played video games for an average of one year. The long-term effects of digital gaming addiction on working memory may differ in the sample group that plays for a longer time. In particular, possible impairments in attention based on game addiction may lead to impairments in working memory. As a result, digital game addiction is related to low attention skills in the short term, but not to working memory. Another result of the present study was that adolescent with digital game addiction displayed higher levels impulsivity. Literature was consistently indicated that impulsivity was related to higher levels of internet gaming disorder (Cerniglia et al., 2019).

Another aim of this research is to determine whether the digital game addiction significantly predicts impulsivity and executive functions variables together with a holistic model. In accordance with this purpose, a meaningful model was obtained, which showed that digital game addiction significantly predicts impulsivity, inhibition, as well as set shifting (cognitive flexibility). Particularly, this research results suggested that an adolescents' higher levels of digital game addiction can override the ability to make effective use of inhibition and set shifting skills and ability to resist impulsivity. These results indicated that both reduced inhibitory control and heightened impulsivity due to high levels of digital game addiction can limit the ability to suppress automatic or dominant responses and control attention, thinking and behavior. In other words, this result showed that adolescent with digital game addiction might displayed higher levels impulsivity. Literature was consistently indicated that impulsivity was related to higher levels of digital game addiction (Cao & Su, 2007; Gentile, 2009; Meerkerk et al., 2010). On the other hand, there are contradictory conclusions regarding the association between inhibition and cognitive flexibility, executive functions and digital game addiction in the literature. Some researchers have yielded positive relationship between the digital game playing and inhibition and cognitive flexibility ability (Castel et al., 2005; Green & Bavelier, 2012; Karle et al., 2010; Steenbergen et al., 2015). However, consistent with the findings obtained from the present study, Farchakh et al. (2020) and Özçetin et al. (2007) revealed the negative correlation between the digital game playing and inhibition. Moreover, according to Cain et al. (2012), Chen and Hsieh (2018), Collins and Freemen (2014), and Samson et al. (2021), there was no significant relationship between video game experience and set-shifting/cognitive flexibility. Consequently, our results demonstrated that some executive functions performance, such as inhibition and set shifting/cognitive flexibility decreased with increasing digital game addiction.

The current research revealed that digital game addiction was not associated with working memory capacity. This finding of the present study is in line with the previous studies conducted by Chen and Hsieh (2018) and Samson et al. (2021) indicating that there was no significant difference in working memory performance of frequent and infrequent video game players. Farchakh et al. (2020) demonstrated that individuals who spend too much time playing the same type of games could have worse working memory capability. In that, in contrast to this study, the current research results yielded that higher levels of digital game addiction were not related to worse working memory capacity. The sample of the current study consists of adolescents who have been playing video games for an average of one year and two and a half hours per week. The current research finding may be due to the fact that the sample group has relatively lower frequency of playing video games. The long-term effects of digital gaming addiction on working memory may differ in adolescents who play video games longer. In particular, possible attention problems based on game addiction may lead to working memory difficulties. As a result, digital game addiction is related to low attention skills in the short term, but not to working memory.

The results of this study should be investigated in line with its limitations. First of all, since the age variable may affect cognitive processes, the age range of the participants was limited to early adolescence. Therefore, these research results can merely be generalized to the early adolescents. Second, this study was conducted via a cross-sectional design. Longitudinal cohort studies should be carried out in order to better to better review the changes in children's cognitive processes over time. Third, the sample is selected by the convenience sampling method. The sampling bias resulting from this method reduces the generalizability of the results. Finally, this study focused on the relationship between digital game addiction and three different executive function functions. Thus, there is a need for future studies examining its relationship with different cognitive functions, such as long-term memory, planning, problem solving and decision making.

This study is important in terms of examining the cognitive processes of healthy children with digital game addiction tendency within the framework of a structural equation model. In particular, a holistic model can contribute to co-evaluation of the relationship between digital game addiction and impulsivity and executive functions, and it allows us to identify which variable may be predicted by digital game addiction. The current research findings indicate that children’s gaming habits may be one of the determinants of their ability to control thoughts and behaviors and cognitive skills. It is necessary to take measures to prevent digital game addiction disorder, impulse control disorders, and anxiety disorders that may result from long-term and misuse of games. It is recommended to organize trainings, seminars, and conferences upon cognitive and behavioral problems related to digital game addiction for parents. Especially, parents should be encouraged to set gaming time limits and spend quality and interactive time with their children. In addition, parents can increase the environments where their children play physical games in order to minimize children's digital game playing addiction. Thus, digital game addiction can be prevented by permitting them to spend less time in front of the screen by their parents. Moreover, units where children and adolescents at risk of digital game addiction can be directed and receive therapeutic support should also be established. Consequently, in terms of applied neuropsychology, the current study provides evidence that digital game addiction is related to worse attention, inhibition, mental flexibility, and impulse control in children. For this reason, it is recommended that cognitive rehabilitation programs are mainly focused on improving these cognitive processes in excessive video gamers.

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