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Relationships between violent video games and cognition

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Abstract

Objectives: The differential effects of playing violent video games on information processing have become an issue of concern. Neuropsychological studies provide inconsistent results regarding the effects of playing excessive video games on information processing. The goal of this study was to investigate the effect of violent video games on various cognitive processes, specifically working memory, object recognition, and visual-spatial perception. The relationships between violent video game addiction and aggression, personality, and craving were also investigated. Method: 54 university students were classified into three different groups (addicted, risk, and control) according to the time they spent game playing and their Game Addiction Scale scores. Results: Game addicted individuals have higher scores on aggression, craving, urging, and psychoticism than other groups. Significant differences in reaction times during cognitive tasks were also found. The game addicted group's reaction times were significantly faster than for risk and non-player groups. Conclusion: This study supports previous findings that violent game playing is related with aggressive thoughts, craving, and urging. However, violent game addiction does not have negative effects on working memory, object recognition, and visual-spatial perception.

Keywords: Game addiction, violent games, aggression, cognition.

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1. Introduction

As the gaming industry has grown over recent decades, an increasing number of people have been considered as addicted to videogames, especially Internet videogames. Although the Diagnostic and Statistical Manual of Mental Disorders IV (DSM IV) does not include gaming addiction as an illness, a lot of evidence supports the idea of game addiction as a syndrome. However, there is disagreement between researchers as to whether online game addiction can be seen as a categorized mental disorder like pathological gambling (Ng & Wiemer-Hastings, 2005). Contrary to expectations, the newly published DSM-V does not identify gaming as an addiction type but lists it as a "condition for further study".

1.1. Game Addiction and Psychological Factors

1.1.1 Game Addiction and Aggression

Many studies show that there is a relationship between game addiction and aggressive behaviours. It was hypothesized that violent video games increase aggressiveness, aggressive behaviours, and aggressive thoughts and feelings (Anderson, 2004; Anderson & Bushman, 2000; Bushman & Anderson, 2002; Lemmens, Valkenburg & Peter, 2011). Anderson and Dill (2000), for example, conducted two experiments (comparing real life violent games versus graphically violent video games) to examine the games' effects on aggression. They found that participants who played violent video games had higher scores for priming aggression related words. In addition to cognition and emotion, playing violent video games also increases aggressive behaviors. Anderson (2004) confirmed that violent video games are significantly associated with decreases in helping and increases in aggressive behaviours. Finally, Lemmens and his colleagues (2011) found that excessive gaming predicted increased reported aggression.

1.1.2 Game addiction and Craving

Because craving has an important role in any form of addiction, it is expected that craving also has a positive relationship with online gaming. Stoeber, Harvey, Ward and Childs (2011) found that craving for online gaming shows the same pattern of emotion as craving for gambling. The neural mechanism of craving in game addiction is also similar to craving in chemical dependence (Ko, Lio, Hsiao, Yen, Yang, Lin, & Chen, 2009). Neurobiological studies indicate that addicted groups show stronger brain activation in the bilateral dorsolateral prefrontal cortex (DLPFC), precuneus, left parahippocampus, posterior cingulate, and right anterior cingulate, and that these activations are positively correlated with gaming urge and craving (Ko, Liu,Yen, Chen, Yen & Chen 2011). Han, Hwang and Renshaw (2010) found significant differences in craving between two groups (violent video game players and non-players). As mentioned above, like substance and other addictions, the neural mechanism of addicted people for craving is different from non-addicts.

1.1.3 Game addiction and Personality

Personality should be examined in order to figure out the etiology of game addiction. Markey and Scherer (2009) found that participants with higher levels of psychoticism were more influenced by violent video games than other participants. People who have high psychoticism scores are defined as less empathic, less fearful, and more hostile, which could explain why people who score high on psychoticism are more aggressive and have more aggressive cognitions after playing violent video games. Exposure to violence also caused approval of violence as a way of conflict resolution (Zillmann & Weaver, 1997).

1.2 Game addiction and Information Processing

1.2.1 Working Memory

Because attention, concentration, reaction time, memory, and hand-eye coordination are key elements in computer games, it is thought that playing games may affect memory (Barlett, Vowels, Shanteau, Crow & Miller, 2009). Working memory (WM) performance requires storing and manipulating visual images, concentration, and executive and attentional control of memory. Based on the common characteristics of video games, playing requires good visualization, image storage, concentration, and selective attention. Thus, it might be assumed that increased practice with games can increase WM performance. Many studies support the idea that playing video games can improve WM because the brain maintains a lifelong capacity for plasticity and adaptive restructuring (Mahncke et al., 2006). Because players must store and remember many stimuli at the same time in order to be successful in video games, playing them may enhance players' WM ability.

1.2.2 Object recognition

Object recognition ability requires recognition memory, concentration, and selective attention. Video games require selective attention and concentration so performing well requires good visuo-spatial abilities. Chrisholm, Hickey, Theeuwes and Kingstane (2010) measured the attention performance of video game players and non-action video game players. Results showed that action video game players responded quicker than non-action video game players when a target appeared with distractors in the display. That is, video game players are significantly faster in conditions requiring visual searching and target differentiation. Castel, Pratt and Drummond (2005) found that video game players had faster reaction times to selected targets. When video game players are exposed to a target appearing with distractors in the display, they responded more quickly than non-action video game players. On the other hand, there are also studies that contradict the claim that video game players are quicker and better at object recognition than non-video game players (for example, Donohue, James, Eslick & Mitroff, 2012).

1.2.3 Visual spatial perception

Computer games require visual spatial abilities because of the need to form a mental image of objects and manipulate them mentally. Thus, it was hypothesized that playing violent video games affects visual spatial memory task performance. Feng, Spence and Pratt (2007) used a training method to examine spatial attention, which is a basic ability that supports higher-level spatial cognition. They found that playing an action video game enhanced spatial attention. They also found that the spatial ability performances of the participants significantly improved after only ten hours training. Similarly, Green and Bavelier (2003) assessed visual spatial performance after exposing participants to violent video games. They found that playing video games was associated with superior visual spatial performance, possibly due to the experience of playing the games. Studies have found that brain activity changes as a behavior becomes habituated. For game addicted people, playing games excessively alters brain activity, with changes to brain pathways becoming more permanent the longer people play. Dye and Bavelier (2010) selected their participants from players who played video games for at least 12 months. They found that the participants demonstrated enhanced visual spatial performance than non-game-playing participants

1.3. Goals of the study

The literature reviewed in the previous section shows contradictory results about the effects of violent video games on cognitive processes. The main goal of this study is therefore to investigate the effect of violent video games on working memory, object recognition, and visual-spatial perception. This study examines the relationships between violent video game addiction, and aggression and personality. The following hypotheses are tested in the present study. Hypothesis 1: There are significant differences in group status (addicted, risk, and control group) in terms of aggression, level of craving, and personality traits, with the addicted group showing higher aggression and craving, and different personality traits to other individuals. Hypothesis 2: There are significant differences in group status (addicted, risk, and control group) in terms of working memory, object recognition, and visual-spatial perception performances, with addicted individuals' cognitive performances being lower than those of other groups.

2. Methods

2.1 Participants

The current study was carried out with 54 participants (20 female, 34 male) aged between 18 and 28. Participants were classified into three different groups according to the amount of time they spent playing games, and their DSM-based pathological game addiction symptoms as adapted from DSM-based pathological gambling symptoms (Gonnerman & Lutz, 2011). In addition, the game addiction scale was used to categorize participants. Three participant groups were formed. The first group (addicted) consisted of 22 students with a mean age of 22.8 (SD=3.1). The first criterion for this group was playing violent video games more than 16 hours a week; the second criterion was marking more than 3 items from the DSM-based pathological gambling symptoms list; the third was having at least 60 points on the game addiction scale. These three criteria represented the group of probable pathological game addicts. The second group (risk) comprised 14 students (age M=21.2, SD=3.2).

The first criterion for this group was playing violent video games for 8 to 16 hours a week; the second was marking one or two items from the DSM-based pathological gambling symptoms list; the third was obtaining 30-60 points on the game addiction scale. This group represented problematic game playing. The last group had 18 participants (age M=23.3, SD=3.4). For this group, the first criterion was not playing any violent video games; the second was obtaining low scores on the game addiction scale; the third was not having any DSM-based symptoms.

2.2 Materials

2.2.1 Psychological Measures

2.2.1.1 Buss-Perry Aggression Scale (BPAQ)

The Turkish adaptation of the inventory was made by Madran (2013). The self-report scale consists of 28 items, using 5-point Likert response scales. A high score indicates a high level of aggression. The scale has four factors: physical aggression, hostility, verbal aggression, and anger. Internal consistency values were .78, .71, .48, and .76 respectively. Test-retest correlations were .98, .82, .85, and .85 respectively.

2.2.1.2 Weiss Craving Scale

This five-item self-report scale was created to measure the craving level of drug addicts. Response options ranged from 0 for "no desire/likelihood of use" to 9 for "strong desire/likelihood of use." The composite score was a sum of these five items, ranging from 0 to 27. It has high internal consistency (Cronbach's Alphas), ranging from 0.85 to 0.90. In the current study, a Turkish adapted form of the scale was used to measure the craving of participants for gaming. The total score can range between 0 and 45. A high score indicates a high level of craving for gaming.

2.2.1.3 The short-form Revised Eysenck Personality Questionnaire (EPQ-S)

The Turkish adaptation of the questionnaire was completed by Karanci, Dirik and Yorulmaz (2007). The scale consists of 24 self-report, yes-no items. The scale has four factors: neuroticism, extraversion, psychoticism, and lie. Each item is rated 0 (no) or 1 (yes). The total score for each factor ranges between 0 and 6. Alpha coefficients for extraversion, neuroticism psychoticism and lie were.78, .65, .42, and .64 respectively, and the test-retest reliabilities were.84, .82, .69, and .69 respectively (Karancı, Dirik & Yorulmaz, 2007).

2.2.1.4 Game Addiction Scale

The Game Addiction Scale was used to measure the participants' level of game addiction of participants. The scale consists of 21 self-report, 5-point Likert scale items. Cronbach alphas range between .80 and .94. A high score indicates a high level of gaming addiction. For the current study, the scale was translated into Turkish and the translation evaluated by two experts, before being revised according to their feedback.

2.2.2 Neuropsychological Assessment

2.2.2.1 Working Memory Task

The task consisted of 3 phases. The stimuli were letters presented against a grey background within a 2 (columns) by 3 (rows) matrix covering an area of 300 x 420 pixels. In the first phase, after a 1000 ms fixation cross, 4 letters were presented randomly in 4 of the 6 possible locations and participants had 1000 ms to encode the identity and location of each letter. After 500 ms, in the second phase, the probe-1 question requested the location of a specific letter. Participants indicated the location using the mouse and were instructed that they had a little time to answer (2000ms) to keep WM delay constant. The third phase had resolvable versus misleading (irresolvable) trials according to whether the probe-1 letter had or had not been part of the encoded set. In the baseline condition probe-1 was omitted to measure working memory performance on the primary task under ideal conditions. A 500 ms inter-stimulus interval (ISI) separated probe-1 and probe-2. Since baseline trials did not include the intermediate probe-1, a grey screen was shown for 5500 ms between encoding and probe-2 (equalling the ISI between encoding and probe-2 on the other trial types). Probe-2 was the actual memory test for each trial, which required participants to indicate if a letter was correctly located with respect to the originally encoded set (2000ms). In all trials, the probe-2 letter was part of the encoded set in terms of identity whereas the probe location was correct in only 50% of trials. Finally, a scale was displayed prompting participants to indicate their degree of confidence in their probe-2 response (6 levels: 1= totally certain to 6= totally uncertain). In the working memory task, the reaction time for correct responses to Probe-1, the reaction time for correct responses to Probe-2, and total reaction time to Probe-2 were recorded and calculated. The reaction time to Probe-2 and the reaction time for level of confidence in Probe-2 were also recorded and calculated to compare the effects of trial type and group status on working memory performance.

2.2.2.2 Object Recognition Task

The task as framed as an object recognition task consisting of 2 phases. In the first phase, the task presented 15 nonsense shapes at a time for 1000 ms against a grey background in the middle of the computer screen. Participants had 1000 ms to encode and learn the shapes. After every presented shape, participants had to choose this shape within a 4 (columns) by 4 (rows) matrix that included 16 different shapes composed of 15 different distractors and one target shape. Participants marked the relevant shape using the mouse, and they were instructed that they had only a little time to click on an item (2000ms). In the second phase, 49 shapes within a 7 (columns) by 7 (rows) matrix were presented on the screen, and participants were expected to remember the target shapes presented during the previous phase. Participants were asked to click on the target shapes among 49 shapes. This phase was not time-limited. Duration of the task was about 10 minutes. Reaction time for correct responses, reaction time for total responses, and total reaction time were recorded and calculated. High response accuracy and short reaction time indicated high performance on the object recognition task.

2.2.2.3 Visual Spatial Memory Task

This task was framed as a visual spatial memory task. The task presented to the participants 40 nonsense shapes at a time for 1000 ms on a screen divided by a white line in the middle. Half of these shapes randomly appeared on the right side and the other of half on the left side in a sequence. In the first phase (learning), participants were asked to monitor and learn the location of the shapes. In the second phase (recognition), the same 40 nonsense shapes were presented in a different order, and participants were instructed to remember the place of the shapes. Participants had to click on the left button of the mouse if the shape was presented in the same place as in the previous phase, or the right button if the shape was presented in the different place in previous phase. The duration of the presentation of each shape was 2000 ms. Each participant had a practice section before the experiment. Reaction time for correct responses, reaction time for total responses, and total reaction time were recorded and calculated.

2.3 Procedure

After necessary approval was obtained from Bahcesehir University Ethical Committee, data collection was started. Selected participants were invited to Bahcesehir University Brain and Cognition Research Laboratory for the assessments. Data collection was completed at one session. Participants were first given the informed consent forms. Then, they were given booklets which included a pack of questionnaires. Then, they were instructed to complete several cognitive tasks. Three computerized tasks were presented: working memory task, object recognition task and visual spatial memory task. The order of these tasks was counterbalanced. Before each task, instructions were given in detail. All the tasks were run with an IBM compatible 15-inch computer running WindowsXP. Administration took approximately 60-90 minutes for each participant.

3. Results

3.1 Group Comparisons on Psychological Variables

3.3.1 Group Comparisons on Buss-Perry Aggression Scale

In order to determine if there is a significant effect of playing violent video games on aggression level, a one-way between-subjects analysis of variance was performed on BPAQ and its subscales. For the total aggression score, the Levene's test was conducted. Homogeneity of variance was satisfactory, F (2, 51) =, 845, p> .05. Results indicated that aggression level was significantly affected by playing violent video games, F (2, 51) = 12.49, p< .01, partial η^2 =.32. Post hoc analysis showed that participants in the risk group had higher aggression scores (M = 83.64, SD = 13.98) than participants in the control group (M = 61.33, SD = 10.75). Addicted participants' aggression scores (M = 77.73, SD = 14.90) were higher than the scores of participants in the control group (M = 61.33, SD = 10.75). For physical aggression, homogeneity of variance was checked. The Levene's test result was satisfactory, F (2, 51) = 1.067, p> .05. Results showed that physical aggression level was significantly affected by playing violent video games, F (2, 51) = 9.18, p< .01, partial η^2 =.26. Post hoc analysis indicated that participants in the risk group had higher aggression scores (M = 23.29, SD = 6.9) than participants in the control group (M = 15.67, SD = 4.6). Addicted participants' aggression scores (M = 22.59, SD = 5.95) were higher than the scores of participants in the control group (M = 15.67, SD = 4.6).

For verbal aggression, homogeneity of variance was satisfactory, F (2, 51) = .167, p> .05. Results indicated that there was a significant difference between groups on verbal aggression scores, F (2, 51) = 3.98, p< .05, partial η^2 =.13. Post hoc analysis demonstrated that addicted participants' verbal aggression scores (M = 15.41, SD = 3.7) were higher than the scores of participants in the control group (M = 12.28, SD = 3.3). For anger, the Levene's test was conducted. Homogeneity of variance was not satisfactory, p< .05. Results indicated that there was a significant difference between groups on anger scores, F (2, 51) = 7.29, p< .01, partial η^2 =.22. Post hoc analysis indicated that the scores of the participants in the risk group (M = 20.71, SD = 4.1) were higher than the scores of participants in the control group (M = 14.94, SD = 3.2).

3.3.2 Group Comparisons on Weiss Craving Scale

In order to examine the difference between groups in terms of craving scores, a one-way between-subjects analysis of variance was carried out for the Weiss Craving Scale. The Levene's test was conducted. Homogeneity of variance was satisfactory, F (2, 51) =, 144, p> .05. Results indicated that the three groups were significantly different on craving scores, F (2, 51) = 35.90, p< .01, partial η^2 =.58. Post hoc analysis indicated that addicted participants' craving scores (M = 25.64, SD = 9.07) were higher than the scores of participants in the control group (M = 5.06, SD = 8.2). Participants in the risk group had higher craving scores (M = 25.79, SD = 9.07) than participants in the control group (M = 5.06, SD = 8.2).

3.3.3 Group Comparisons on the short-form Revised Eysenck Personality Questionnaire

In order to examine differences between groups in terms of personality traits, a one-way between-subjects analysis of variance was carried out for the neuroticism, extraversion, lie and psychoticism subscales of the EPQ. For psychoticism, homogeneity of variance was satisfactory, F (2, 51) =, 820, p> .05. There was a significant difference between groups on psychoticism scores, F (2, 51) = 4.95, p< .05, partial η^2 =.16. Post hoc analysis indicated that the addicted participants' psychoticism scores (M =

2, *SD* = 1.1) were higher than the scores of participants in the control group (*M* = 1.06, *SD* = .94). Participants in the risk group also had higher psychoticism scores (*M* = 2.14, *SD* = 1.2) than participants in the control (*M* = 1.06, *SD* = .94).

3.4 Group Comparisons on Neuropsychological Variables

3.4.1 Group Comparisons on Working Memory Performance

In order to determine whether there was a significant effect of playing violent video games on participants' working memory performance, a one-way between-subjects analysis of variance was performed on the working memory variables: recall correct scores, recall incorrect scores, recognition correct scores, recognition incorrect scores, confidence scores, and total reaction times for all correct, incorrect, and confidence scores. For all variables, the Levene's test was conducted. Results showed that although homogeneity of variance was satisfactory for all variables ($p > .05$), the groups were not significantly different ($p > .05$).

3.4.2 Group Comparisons on Object Recognition Performance

In order to examine the differences between groups in terms of object recognition performance, a one-way between-subjects analysis of variance was performed on the object recognition variables: reaction time for all correct and incorrect scores. For all variables, homogeneity of variance was satisfactory, $p > .05$. Results indicated that there was a significant difference between groups in terms of reaction time for incorrect recognition in the first phase, $F(2, 43) = 3.71$, $p < .05$, partial $\eta^2 = .15$. Post hoc analysis showed that the control group had higher incorrect recognition scores in the first phase (*M* = 2484.6, *SD* = 265.3) than participants in the risk group (*M* = 2135.5, *SD* = 426.6). For reaction time for incorrect recognition scores in the second phase, the three groups were significantly different, $F(2, 49) = 5.31$, $p < .01$, partial $\eta^2 = .17$. Post hoc analysis demonstrated that the addict group (*M* = 5044.4, *SD* = 2015.7) had faster reaction times for incorrect responses than the control group in the second phase (*M* = 8591.1, *SD* = 4132.1)

3.4.3 Group Comparisons on Visual Spatial Memory Task

In order to examine differences between the three groups in terms of visual spatial memory performances, a one-way between-subjects analysis of variance was carried out for the visual spatial memory variables: reaction time for correct scores and reaction time for incorrect scores. For reaction time for correct scores, homogeneity of variance was not satisfactory, $p < .05$, but the three groups differed significantly in reaction time for correct scores, $F(2, 51) = 3.90$, $p < .05$, partial $\eta^2 = .13$. Post hoc analysis demonstrated that participants in the control group had higher reaction times for correct scores (M = 1242.9, SD = 238.6) than participants in the risk group (M = 943.2, SD = 392.3. There was also a significant difference between groups in terms of reaction time for incorrect scores $F(2, 51) = 5.053$, $p < .05$, partial $\eta^2 = .16$. Post hoc analysis demonstrated that the participants in the control group had higher reaction times for incorrect scores (M = 1284.9, SD = 251.7) than participants in the risk group (M = 945.7, SD = 365.2).

4. Discussion

The present study aimed to investigate the effects of violent video games on three psychological factors: aggression, craving and personality. It also analyzed the effects of violent video games on three cognitive factors: working memory, object recognition, and visual-spatial perception.

4.1 Effects of Violent Games on Psychological Variables

It was hypothesized that aggression level is affected by group status (addicted, risk and control). As expected, for total aggression and physical aggression, the risk and addicted groups had higher scores than the control group. For verbal aggression, participants in the addicted group had higher scores than the control. For anger, the participants in the risk group had higher scores than the control. These results are thus in line with previous studies showing that significant relationships between playing excessive violent video games, aggressiveness, aggressive behaviours, and aggressive thoughts and feelings (Anderson, 2004; Anderson & Bushman, 2000; Bushman & Anderson, 2002; Lemmens, Valkenburg & Peter, 2011).

We did not find a significant difference between the risk and addicted groups on anger variable, perhaps because of the effect of exposure to violence. Even if the exposure is short, its effect may be similar to heavy exposure. Bushman and Anderson (2002) found that playing a violent video game for just 20 minutes led participants to handle potential conflict situations aggressively. Because both the addicted and risk group were exposed to violent video games, even if there is a difference between their levels of aggression, this difference could not be detected because of desensitization and exposure effects. Another explanation for not being able to find a significant difference between the addict and risk group on aggression might be that some participants spend similar amounts of time on game playing even though they were placed in separate groups.

Although the amount of time spent for game playing, DSM-based pathological game addiction symptoms, and game addiction scale scores were correlated and were useful to differentiate the control group from the others, they may not have been sufficient to distinguish the two groups addict and risk). Both groups were affected by violent video games and had higher scores on aggression than the control; however, it could be difficult to differentiate their levels of aggression. Lastly we did not measure onset of violent game playing, which could have created co-variance between the groups. This issue should be controlled for in future studies.

Like aggression, we hypothesized that craving level is influenced by group status. Our results indicated that for the craving scale, the three groups were significantly different. Participants in the addicted and risk group had higher craving scores than the control group. Ko et al. (2009) showed that the neural mechanism of gaming urges or craving in online gaming addiction is similar to cravings in substance dependence. As expected, our results showed that the craving scores of addicted participants were higher than the control group. Just as substance-related cues stimulate substance-seeking behaviour and substance consumption, EEG studies show that computer game players perceive computer game cues as significantly more arousing (Thalemann, Wölfling & Grüsser, 2007). In addition, addicted participants show stronger brain activation during fMRI recording, with activation of the bilateral dorsolateral prefrontal cortex (DLPFC), precuneus, left parahippocampus, posterior cingulate, and right anterior cingulate being positively correlated with craving scores (Ko et al, 2011). Thus, it can be concluded that the behavioural and neurobiological mechanisms of craving in addicts are different than in non-addicts. Lastly, the present findings support the idea that craving is an important and distinguishing factor in game addiction.

In this study, it was also hypothesized that there is a significant difference between groups in personality characteristics. Consistent with previous studies (Markey & Scherer, 2009; Zillmann & Weaver, 1997), the current findings support the claim that psychoticism scores of addicted participants are higher than non-addicted participants. Participants in the risk group also had higher psychoticism scores than those in the control group. People with high psychoticism scores tend to show less empathy, less fear, and more hostile behaviours. They are more likely to be cold, unemotional, unhelpful, and antisocial. Markey and Scherer (2009) found that participants with higher levels of psychoticism were more affected by violent video games than other participants. This could explain why people who score high on psychoticism are more hostile and have more aggressive cognitions after playing violent games than people with low levels of psychoticism. Thus, it can be assumed that participants who are excessively exposed to violent video games could become more hostile over time, and that people who have characteristics of psychoticism tend to play more violent video games.

4.2 Relationships between Violent Game Addiction and Neuropsychological Processes

Our study failed to differentiate between the groups in terms of working memory, although this may be explained by the design. Compared to previous studies that found a significant difference in WM performance, the current study did not include practice and training phases. The participants in our study also reported their estimated amount of time that they spent playing violent video games each week. Thus, it might be more effective to control for participants' exposure and playing time in the laboratory setting. In addition, the amount of time participants spend playing violent video games is also a crucial factor. We categorized participants into groups according to the amount of time spent playing video games per week; however, this did not take into consideration how long they had been playing video games in total. Colzato et al. (2013) studied participants who had played video games at least 5 hours per week for a minimum of 1 year. They found that violent video game players showed more accurate WM performance. Our sample may have included participants who had only played violent video games for a short time, which could have influenced the WM performance results.

In addition to working memory, our study examined object recognition performance. Results showed that participants in the control group have longer reaction time for incorrect scores than participants in the risk group. They also demonstrated that participants in the control group have longer reaction times for incorrect recognition in the second phase than participants in the addict group. This indicates that the risk and the addict groups gave incorrect responses more quickly than the controls, which can be explained by the impulsiveness of game players. Internet and video game addiction are seen as a type of impulse control disorder (Treuer, Fábián & Füredi, 2001), and this is supported by research. For example, Cao, Su, Liu, & Gao (2007) found that internet addicts show more impulsivity than controls. In order to understand the neurobiological bases of internet addiction, imaging studies have investigated differences in brain regions. It was found that internet users exhibit greater impulsiveness than normal users, and that there is a strong positive relationship between impulsiveness and severity of internet use.

Compared to normal users, over-users had increased glucose metabolism in the right middle orbitofrontal gyrus, right insula, and left caudate nucleus, and decreased metabolism in the bilateral postcentral gyrus, left precentral gyrus, and bilateral occipital regions (Park et al., 2010). They found that gaming excessively can be related to abnormal neurobiological mechanisms in the orbitofrontal cortex and sensory regions, which are associated with impulse control. In an MRI study, Han, Lyoo, and Renshaw (2012) found that, compared to a healthy group, patients with online game addiction showed increased impulsiveness errors and increased volume in the left thalamus gray matter but decreased gray matter volume in the right middle occipital gyrus, inferior temporal gyri, and left inferior occipital gyrus.

Another important cognitive ability examined in this study was visual spatial ability. Results showed that the three groups were significantly different in terms of total reaction time for total correct scores. Post hoc analysis demonstrated that participants in the control group have longer total reaction times for total correct scores than participants in the risk group. This means that participants in the control group took more time to find the correct answers than did participants in the risk group. This can be explained by the speed of the players, as mentioned above. The results also indicated that there is a significant difference between the groups in terms of reaction time for incorrect scores. Participants in the control group have longer total reaction times for incorrect scores than participants in the risk group. These results support the idea that participants who play violent video games have faster response times on attentional tasks than non-players (Subrahmanyam, Greenfield, Kraut & Gross, 2001).

4.5 Limitations and Strengths of the Study, and Recommendation for Future Research

This study makes a crucial contribution to the game addiction literature. To date, few studies have examined how psychological and cognitive factors affect game addiction. Some studies have examined the effects of a few psychological factors or only cognitive factors. This study, however, took into consideration many psychological and cognitive factors together, making it one of the first studies to integrate cognitive and psychological mechanisms in gaming addiction. In addition, it extends the gaming literature on identifying the criteria and symptoms of game addiction. One contribution is to distinguish addicts from the non-addict population and the risk population by getting information from several sources (game addiction symptoms, scores for game addiction, craving, and urge scales). Finally, many studies present just two groups: the addict group and the control. In this study, however, three groups were used to increase the accuracy of the results. The study shows that people in risk group can be effectively identified using different inclusion and exclusion criteria.

However, there are several limitations to take into consideration. The main limitation is the small sample size. A larger sample might yield different results. In addition, because it was hard to reach the participants who play violent video games, the groups could not have equal participant numbers. Consequently the risk and addict groups may not have been able to significantly differentiate task performance. Further studies could include more participants. Another difficulty in a video game study concerns the differences between types of the games participants play. The main factor that affects cognitive ability is the characteristic of the games, and participants play many different types of games. Because we did not expose every participant to the same type of game, the games' perceptual and cognitive effects cannot be so easily compared. While some participants regularly play first-person shooter games, others may play third-person shooter or strategy games.

Thus, the effects and changes in cognition and perception may not be similar. Another limitation is that the sample was not diverse as participants were all undergraduate or graduate students from the same region. High school students or participants from different regions may have different characteristics related to game addiction. This study examined the adult population. However, it is plausible that high school students and teenagers should be studied because violent video gaming is becoming increasingly popular among teenagers. Thus, to form a risk group and compare the characteristics of the addicted and risk groups, a young population should be involved in such studies. Thus, it is also not possible to generalize the results of the study for all the population.

4.6 Clinical Implications of the Study

On the basis of the current results, aggression has a relationship with game addiction. For clinicians, it is important to be aware of the anger and aggressive behaviour of the client, and anger should be studied in therapy together with addiction. Therefore, psychological interventions might aim to decrease craving for playing, and it might be important to intervene with addicted people to develop effective anger regulation strategies and enhance control over their impulses. We also found that aggressive thoughts, feelings, and behaviour, and also high levels of psychoticism may result from playing video games. Finally, we found that addicted participants show more impulsive behaviour than risk and control groups in terms of their reaction times to cognitive tasks. This is important information in a clinical respect because gaining control over impulsiveness can be worked on in therapies and clinical practice.

The most important contribution of this study to the literature might be in helping to define game addiction as a DSM-based pathology. If defined as an illness, this will encourage people who suffer from symptoms related to game addiction to ask for professional help more easily. Before the illness becomes serious, it can be noticed, which can help to reduce hospitalization and potential medical problems. Accepting that excessive use of internet and gaming are severe problems can also decrease prejudice in public perceptions of problematic gaming. If accepted as a diagnosis, this will support more research into this issue. Finally, an illness category can provide necessary payments for health care from governments and insurance provider, which may help to finance the necessary treatment.

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