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The effect of violent and non-violent computer games on cognitive performance

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ABSTRACT

Two studies were conducted in order to determine the impact computer games had on the cognitive performance. Study 1 evaluated a measure of cognition, which incorporates aspects of short-term working memory, visual attention, mathematical decision making, and auditory perception. Study 2 measured the cognitive performance between those who did not play video games versus those who played either a violent or non-violent video game. Results from Study 1 indicate participants needed approximately four trials to reach asymptotic performance on the cognitive measure. Results of Study 2 showed that participants who did not play any video game did not have a change in their cognitive performance, while those who played either a violent or non-violent video game had an increase in their cognitive performance.

1. Introduction

Researchers, especially cognitive psychologists, have been investigating the possible societal value of playing various computer games. For instance, as early as 1983, Lynch stated that cognitive abilities, such as attention, concentration, reaction time, visual tracking, memory, hand-eye coordination, mathematical ability, and verbal ability were key components in computer games. Computer game research had become so prominent by 2004 that the term ludology was created to define such work (Wadhams, 2004). Specifically, researchers have focused on the possible increased cognitive performance that could be produced by computer game play. Overall, the research has examined four overarching constructs, each of which will be briefly reviewed.

1.1. Visualization

Visualization refers to the ability to mentally manipulate visual patterns (Colom, Contreras, Shih, & Santacreu, 2003). Duesbury and O'Neil (1996) found that the ability to visualize a 3-D object from a 2-D object can be increased with practice. Part of this spatial ability relies on using a constructive strategy (forming a mental image of the whole object first then trying to perform the task) instead of an analytical strategy (where the drawings are simply compared and features are matched). Applying the construct of visualization to computer game play, Sims and Mayer (2002) found that skilled Tetris players were better able to use visualization to mentally rotate the block shapes (that resembled the Tetris blocks) than non-Tetris players.

1.2. Concentration/selective attention

Selective attention is the ability to focus on relevant information that is pertinent to the task, while filtering out or irrelevant information (Sternberg, 2003). Blumberg (1998) found that skilled computer game players performed better on a popular computer game (Sonic the Hedgehog for Sega Genesis); because they were better able to concentrate on specific game features. This study suggests that those who play computer games frequently are more apt to focus their attention on relevant information that is important for success at their specific task. Similar results found that those who play computer games frequently have an increased attentional capacity and useful field of view (Green & Bavelier, 2003).

Ariely (2000) observed that the ability to control information leads to better ability to create relationships between concepts, understand information better, increase memory-accuracy and memory-structure, and improve reasoning ability. In addition, information control increases the ability to process and integrate information. Kuhn and Ho (1980) found that children who chose the games they played were able to create new reasoning strategies (compared to those with no choice). These researchers believed this was because the children have anticipated schemas about outcomes, indicating the improvement is both global and specific.

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Additional research, focusing on concentration, found self-reported reductions in pain of burn victims when these victims were to play a virtual reality computer game (Hoffman, 2004). It is speculated that this occurs because the virtual world requires patients to devote most of their concentration and attention to analyzing and responding to the game, which leaves very little capacity left to process the pain response. In other words, by concentrating on this 3-D game, participants were unable to attend to, and thus feel, their pain as intensely.

1.3. Scanning

Scanning is defined as repetitive sequences of fixations and saccades that occur upon re-exposure to a visual stimulus, facilitating recognition of that stimulus (Noton & Stark, 1971). Shapiro and Raymond (1989) reported that trained visual strategies could be transferred to similar tasks, in this case performance in the game space fortress. Training focused on saccadic eye movements and smooth pursuit eye movements which combine to form the scan path. One reason an effective scan path is useful is that when the eye is involved in saccadic movement, visual detection is reduced, i.e., the fewer and more appropriate saccades are, the more efficient the visual scan is. Findings indicate that scan patterns are controllable, and that both components can be improved upon. Additionally, "good" scanning habits can be transferred to a second task, assuming it relies on the same visual strategy (Shapiro & Raymond, 1989).

1.4. Tracking

Even though there may be many forms of tracking (i.e., visual), tracking in the computer game literature is viewed as a dual process consisting of hand tracking (using the keyboard/controller) and visual tracking (attending to objects on the screen). Bliss, Kennedy, Turnage, and Dunlap (1991) showed that certain computer games can be used as a test of tracking ability, instead of traditional tests (i.e., critical tracking test, compensatory tracking test, and dual-tracking test). Some games suggested as alternatives include air combat maneuvering, race car, and breakout. High correlations between standardized measures of two-dimensional compensatory tracking performance and computer game performance occur because both the tests and the games presumably tap the same underlying ability, suggesting computer games may provide a good assessment of tracking.

Visual scanning and visual tracking performance for participants with minimal brain damage or hyperactivity increased after 12 h of training on the video game super breakout (Larose, Gagnon, Ferland, & Pepin, 1989). This suggests that certain computer games, especially those mentioned previously can increase tracking abilities.

1.5. Overall implications of computer game studies

Overall, the literature has shown that playing video, or computer, games can significantly increase cognitive performance, however cognitive performance is operationally defined. Specifically, visualization, tracking, scanning, concentration, and selective attention all increase after playing a wide variety of games. However, these cognitive abilities do not exist independently of one another. Therefore, research has been conducted which looks at combinations of cognitive abilities, rather than just one specific ability at a time.

One example of such a study was conducted by Kearney (2005) who used a computer assessment tool, SynWin (Elsmore, 1994), and a first-person shooter computer game (counter strike) to determine if video game play was related to general cognitive performance. SynWin is a computer program used to measure cognitive abilities (working memory, visual attention, auditory attention, and foresight) simultaneously. Kearney (2005) had participants play SynWin for three sessions. Participants played SynWin twice for practice, played the violent video game counter strike, and then they were tested using SynWin as a post-game comparison. The results show that scores on SynWin increased the greatest for those participants that played counter strike compared to those who did not (Kearney, 2005). The findings suggest that playing a violent first-person shooter game can significantly increase scores on SynWin, which is designed to measure cognitive abilities.

However, even with the possible generalizations that can be made from the Kearney (2005) study, it has limitations. First, participants familiar with computer games were only recruited, making generalization to the entire population difficult, and the amount of computer game experience was not examined. Second, participants may not have been given enough practice trials of the cognitive measure. It is clear from the results that not all participants were at a comparable level, because all scores on the cognitive measure increased independent of condition. Although not applicable to the Kearney (2005) study, the majority of video games used in past research are non-violent. According to the video game classification system by Griffiths (1999), most games used fall under the "puzzler" or "miscellaneous" categories, such as Tetris or super breakout. It is only recently that researchers have begun to investigate the cognitive abilities elicited from violent video games, such as counter strike and golden eye. To date, there has not been any published research that has compared the effects of violent and non-violent video games using the SynWin cognitive measure.

1.6. Objectives of the current research

The primary focus of the current research was to examine whether or not content of a computer game significantly moderated the possible cognitive benefits of playing such games. Upon review of the research, it is clear that both violent and non-violent video games have the ability to enhance the cognitive abilities of players because of the vast amount of stimuli that players have to respond and attend to in order to succeed in the video game. However, the literature is unclear as to whether or not the content of the video game influences such an effect. Some past literature has used both violent and non-violent video games in the same study (e.g., Green & Bavelier, 2003); however, we are unaware of any published study which has compared the two types of content.

Also, we are unaware of any published research study which has compared violent and non-violent video game play on general cognition, which is operationally defined as the summation of a number of specific cognitive variables (e.g., attention, learning, hand-eye coordination, and so forth). General cognition is the primary dependent variable investigated, rather than specific cognitive variables, because the literature has been mixed regarding the impact that video games have on specific cognitive variables. For instance, Duesbury and O'Neil (1996) found a non-significant relationship between video game play and spatial abilities, while De Lisi and Wolford (2002) did find a significant relationship between video game play and spatial abilities. It is speculated that differences between the video games used and measures of spatial abilities attribute to this discrepancy, which is the reason why general cognition is the primary focus of the current research. We believe that before specific cognitive variables should be measured, general cognition should be the focus, then if results of the current study replicate past research using general cognition as the primary dependent variable, then specific cognitive variables should be investigated.

The current research also addressed some of the problems in the past literature, as well as the Kearney (2005) study. First, we had participants engage in multiple SynWin trials to ensure that any observed change in the scores of this measure were not a function of practice effects. Second, we did not specifically sample video game players. Thus, the generalization of the findings can be applicable to more than just game players, like in the Kearney (2005) study.

2. Study 1

2.1. Overview of the current study

This was a pilot study to gauge how many trials are needed to reach asymptote on the criterion measure used in the primary study. The results from this study will be used to determine the number of trials needed to observe asymptotic behavior on the cognitive measure, which will be the proxy of how many trials are necessary in order to ensure that practice effects are not a viable explanation for any change in the criterion measure.

3. Method

3.1. Participants

Participants were 37 students (28 male) who received partial course credit in their General Psychology class for their participation. The average age was 19.38 years (SD = 1.02 years). Data from two participants was removed from the analysis due to a data-recording error, leaving 35 participants. The majority of the participants were Caucasian (91.2%) who played video games an average of 0.79 (1.01) hours during weekdays and 1.71 (2.05) hours during weekends.

3.2. Materials

3.2.1. Cognitive measurement

The computer program, SynWin, was used to assess cognitive skills. The program has four different tasks, one in each quadrant, which are played simultaneously. The first sector tests for working memory, by using the sternberg task. Participants committed a set of six letters (set size list) to working memory. After the display was off, a test letter appeared that was either a foil (not in memory set) or a target (in the memory set). The participants' task was to say if the test letter was, or was not in the memory set. Participants received ten points for a successful response, and penalized ten points for an incorrect response.

The second sector was a task of adding three numbers, e.g., to add 482 to 123, or 193 to 12. This is the only sector not timed. Participants were awarded 20 points for a correct answer and penalized 20 points for an incorrect answer.

The third sector was an auditory perception task. Participants heard a series of high and low pitched tones over headphones. Participants' task was to click a button on the screen which signifies that they heard the high tone but were to ignore the low tones. A correct response was worth ten points. If participants did not respond to the high tone, or responded to a low tone, ten points are penalized.

The fourth sector was a selective attention task which depicted a gas gauge with three colors, each representing a stage of fuel levels, and a needle. Throughout the course of this computer game, the bar slowly moved from the right to the left of the gas gauge. The task was to keep the bar from reaching the left hand side of the meter indicating the fuel was empty. However, every second that the needle was not moving, ten points was penalized. If participants clicked on the bar when it is in the red zone (immediately prior to being completely empty), then the participant was awarded points depending on where the needle was on the gauge, and the needle restarted on the right side.

Each of the four sectors operated concurrently and participants needed to attend to all of the sectors at the same time. Each SynWin trial lasted five minutes. The participant's composite score appeared in the middle of the screen, which gave the participants feedback on their performance.

3.2.2. Demographic questionnaire

Participants answered questions about their gender, age, ethnicity, and computer game play experience. Specifically, the participants were asked how often they played video or computer games on the average weekday and weekend.

3.3. Procedure

Initially, participants were told how to play each sector of SynWin. Participants then completed five SynWin trials. Each trial lasted five minutes. Upon completion, participants completed the demographic questionnaire, were thanked, and fully debriefed.

4. Results

The results showed that participants needed an average of four sessions to achieve an asymptotic level on SynWin. As seen in Table 1, performance peaks in the fourth session and descends slightly in the fifth session, possibly due to possible fatigue effects.

In order to test whether performance on SynWin significantly increased over time, a repeated measures analysis of variance was conducted. There was a difference in the composite score across the five trials [$F(4, 132) = 73.49$, $p < .0001$, partial $\eta^2 = .69$], which suggests overall improvement across the entire study. A Bonferroni post hoc analysis was used to control for family wise error rates. There were significant ($p < .0001$) improvements from trials one to three and smaller, significant improvements across sessions three and four. At trial 4, the SynWin scores no longer increased, hence asymptotic behavior was observed (see Table 1).

Kearney (2005) sampled from a population of video game players. Therefore, his sample was from a population that already had certain cognitive abilities from playing computer games. That suggests that the number of hours spent playing video games needs to be statistically analyzed to alleviate this potential criticism. A linear regression analysis was conducted with the number of hours spent playing video games as the independent variables and the SynWin score on trial 5 as the dependent variable. The results were non-significant [$R^2 = .04$, $F(2,33) = 0.70$, n.s.]. Therefore, the number of hours spent playing video games is not a significant predictor of SynWin scores.

Finally, frequency distributions were constructed for the SynWin data. It was found that all of the trials had a high degree of skewness and kurtosis. Furthermore, correlation analyses reveal that SynWin trial 4 and SynWin trial 5 were highly correlated with one another, $r = .96$, $p < .0001$, which violates the assumption of

Table 1
SynWin mean scores and standard deviations for study 1 for each trial

Trial 1 *Session Average*[*]	Trial 2	Trial 3	Trial 4	Trial 5
−864.32 (905.69)	224.18 (557.80)	357.50 (579.21)	498.44 (562.21)	440.94 (587.60)

[*] $p < .001$ assessed using a repeated measures ANOVA.

multicollinearity. The extent to which these findings are problematic for Study 1 is minimal, because the focus of this current study was to determine how many trials were necessary to reach asymptotic behavior. However, future studies need to test for violations of the General Linear Model (GLM), such as multicollinearity and non-normality, before conducting any analyses.

5. Discussion

This study was conducted in order to determine the number of trials needed to reach asymptote on SynWin. Overall, participants needed four trials in order to have asymptotic behavior. The results also show that the amount of time spent playing video games did not significantly predict scores on SynWin. This suggests that the experience of playing video games does not influence SynWin performance. Finally, future studies need to check for violations of the General Linear Model as the SynWin data may violate multicollinearity and non-normality.

6. Study 2

6.1. Overview of the current study

There were several purposes of the current study. The first was to determine the extent that violent versus non-violent video games had on cognitive performance. The second purpose was to determine the extent that violent and non-violent video games versus not playing a video game have on cognitive performance. Based on the past research, the following hypotheses were derived:

- H_1: As seen in Study 1, it will take participants four trials on the SynWin computer program to reach asymptotic behavior.This hypothesis will be supported if there is no substantial difference in the mean SynWin score between trials 4 and 5. If supported, this finding will replicate the results of Study 1. Also, violations of the General Linear Model will be tested.
- H_2: Participants who play either a violent or non-violent computer game will outperform those participants on SynWin compared to those who do not play games on trial 5.This hypothesis was derived based on the past research which has shown that video games (either violent or non-violent) will increase cognitive performance. It is predicted that those participants who do not play video games will have a decrease in cognitive performance because these participants will not receive the increased skills (e.g., attention) that the video game playing participants will receive.
- H_3: There will not be a difference between those who play a violent versus non-violent video game on SynWin scores on trials 4 and 5.Upon reviewing the literature, there has not been any published research which has specifically tested violent versus non-violent video games against one another to determine if there are differences between these two types of games on cognitive performance. It is predicted that there will not be a difference between these two types of video games because participants should still be receiving the increased skills to perform well at SynWin trial 5.

7. Method

7.1. Participants

There were 113 (57 male) participants with the majority being (87.6%) Caucasian. The average age for this sample was 19.18 (SD = 1.54) years. For taking part in this study, all participants received partial course credit for their General Psychology class. The average video game play during a weekday was 0.77 (SD = 1.07) hours and the average video game play during the weekend was 1.78 (SD = 4.19) hours.

7.2. Materials

7.2.1. Computer programs

SynWin was used to assess cognitive performance. The four cognitive measures assess working memory, auditory perception, visual attention, and mental addition. Two non-violent computer games were used. The first game was the tile game. The object is to remove all of the tiles by matching them to their duplicate. This game lasted ten minutes. The second game was marked numbers. This game presents fifty numbers, with instructions to identify numbers falling within a certain range, e.g., select odd numbers between 3 and 17. This game lasted for four minutes. These video games were selected because they are clearly non-violent and are similar in style to computer games used in past research.

The violent video game that was used was Red Alert 2 by Westwood studios (2000). The purpose of this video game is to build a military base, defend that base from enemy attacks, and destroy the opposing army's troops and base. The viewpoint is that of a third person shooter game in which the goal is to select an area to place troops and to attack enemy forces. Participants are given $10,000 to build an army from a given country and to destroy the army of an opposing country. Participants have the ability to generate more money and spend it on a number of buildings (e.g., barracks, ore refinery, satellite, war factory), a variety of vehicles (e.g., tanks, fighter planes, helicopters), and troops (e.g., basic infantry, specialists in explosives, engineers, attack dogs).

7.2.2. Demographic scale

A demographic questionnaire was utilized which assessed the participant's gender, ethnicity, and video gaming experience. Also, the participants were asked to rate how much concentration was needed to complete the video game(s) and how much of an expert on the SynWin trials they felt they were on a one (not at all) to nine (extremely) Likert scale.

7.3. Procedure

Participants were randomly assigned to three groups: the control group ($n = 54$), the non-violent video game experimental group ($n = 27$), and the violent video game experimental group ($n = 32$). Upon completion of the informed consent and experimental research cards, the participants completed SynWin four times. Upon completion, participants in the non-violent experimental condition played one session of marked numbers for four minutes, the tile game for ten minutes, and the marked numbers game again for four minutes. Participants in the violent experimental condition played Red Alert 2 for 18 min. Finally, participants in the control condition used the internet to search for information relating to air traffic controllers for 18 min. This filler task was used in order to keep the participant's hand-eye coordination constant. All groups then completed the fifth and final SynWin trial and then the demographic questionnaire. All participants were then thanked and fully debriefed.

8. Results

A repeated measures ANOVA was conducted, which revealed a significant improvement across the five SynWin trials [$F(4, 448) = 142.13$, $p < .0001$, partial $\eta^2 = .56$]. The means of the five SynWin trials were compared using a Bonferroni correction, to control for family wise error rates. Thus, there was overall improvement on the five trials.

Prior to conducting the main analysis, the data was inspected for violations of the General Linear Model (GLM). First, the data for trials 4 and 5 were highly correlated with one another, $r = .84$, $p < .0001$, which violated the assumption of multicollinearity (Tabachnick & Fidell, 2001). To alleviate this problem, the data were centered which reduced the correlations. The centered and non-centered distributions of SynWin trials had high skewness and kurtosis, violating the assumption of normality. Therefore, the data was transformed by taking the log of the absolute value, as suggested by Tabachnick and Fidell (2001). The absolute value was taken because one cannot take the natural log of a negative number (this only occurred at trials 1 and 2, however, since these were not the critical comparison trials, taking the absolute value did not significantly impact the results). Further analyses did not reveal subsequent violations of the GLM; therefore, the main analyses could be conducted.

A two (time: trials 4 and 5) X three (condition) mixed analysis of variance was conducted with time as the within-subjects factor. The log transformed centered mean SynWin scores for trials 4 and 5 was the dependent variables. The previous SynWin trials were not necessary to analyze here because all participants, independent of condition, complete trials 1 through 4 without differing in procedure. The results showed a significant main effect for time [$F(1,110) = 12.41$, $p < .01$, partial $\eta^2 = .10$], however this results was qualified by a significant time X condition interaction [$F(2,110) = 3.17$, $p < .05$, partial $\eta^2 = .05$]. There was a non-significant main effect for group.

A simple effects analysis was conducted to probe the significant interaction. The results showed that there was a non-significant change [$F(1,110) = .12$, n.s.] in cognitive performance from trial 4 ($M = .02$, SD = .35) to trial 5 ($M = .02$, SD = .37) for those in the control condition. There was a significant increase [$F(1,110) = 9.418$, $p < .05$.] from trial 4 ($M = -.03$, SD = .46) to trial 5 ($M = .07$, SD = .33) for the non-violent video game condition. Finally, there was a significant increase [$F(1,110) = 5.29$, $p < .05$] from trial 4 ($M = .05$, SD = .35) to trial 5 (M = .13, SD = .35) for those in the violent video game condition. In order to ensure that these results are not qualified by differences at trial 4 between the three conditions, a one-way analysis of variance was conducted, which showed a non-significant main effect for condition [$F(2,110) = .39$, n.s.]. See Table 2 for these results.

In order to test whether or not there was a difference in cognitive performance after video game play between the three conditions, an analysis of covariance (ANCOVA) was conducted with group as the independent variable, and the transformed SynWin score at time 4 as a covariate. The results showed a significant main effect of condition [$F(2,109) = 3.33$, $p < .04$, partial $\eta^2 = .06$]. The SynWin score at time 4 was a significant covariate [$F(1,109) = 346.58$, $p < .001$, partial $\eta^2 = .76$], as expected. However, pairwise comparisons with a Bonferroni correction showed that the violent and non-violent video game condition did not significantly differ from one another [$ps > .07$]. This suggests that the violent and non-violent video game players had similar cognitive gain.

Finally, a hierarchical linear regression was conducted in order to determine if individual difference variables (i.e., gender, hours spent playing video games) and the amount of effort (i.e., concentration and expertise) would significantly impact the overall relationship, with the difference between the transformed SynWin trials 5 and 4 score as the dependent variable. Gender of the participants was entered into the regression equation at step 1, the number of hours spent playing video games was entered at step 2, and the amount of concentration and expertise in the video game were both entered into the final step of the regression equation. The results showed that none of the steps accounted for a significant portion of the variance in SynWin change [all $R^2 < .10$, all Fs < 1.8, all $p > .05$].

Table 2
SynWin Scores for each trial in study 2 by group

Group	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Untransformed data[*]					
Control	−112.27 (573.39)	281.56 (632.82)	438.05 (447.53)	561.81 (304.24)	552.24 (207.75)
Non-violent	−444.81 (571.11)	242.81 (392.09)	456.48 (231.13)	558.29 (269.05)	532.33 (252.30)
Violent	−283.37 (765.20)	151.07 (886.07)	340.00 (635.83)	560.56 (311.72)	519.19 (243.18)
Transformed data (centered and natural log)[*]					
Control	−.00 (1.14)	.01 (.85)	.03 (.75)	.02 (.35)	.03 (.37)
Non-violent	.03 (1.64)	−.09 (.67)	.00 (.43)	−.04 (.46)	.07 (.33)
Violent	.06 (1.31)	.06 (.97)	−.08 (1.08)	.05 (.35)	.13 (.35)

The sample sizes are as follows: control $n = 59$, violent $n = 27$, non-violent $n = 27$.
[*] $p < .001$ assessed by using a repeated measures ANOVA.

9. Discussion

This study examined the effect that playing two non-violent computer games had on the cognition performance. All participants performed a cognitive assessment task five times. The first four trials were used as practice with the fifth trial as a post-treatment comparison. Those participants in the control condition did not change in their cognitive performance. Those in the violent and non-violent video game conditions did have a significant increase in their cognitive performance.

There are several conclusions that can be drawn from these findings. The first is that playing either a violent or non-violent video game increased cognitive performance, which suggests that there is a transfer of skills from the video game to SynWin performance. The second conclusion is that there was a similar increase in cognitive ability for both types of video games, which suggests that content does not seem to affect the overall cognitive outcomes of video game play.

10. General discussion

The objective of the current research was to examine the role that violent versus non-violent video games had on cognitive performance, relative to those who did not play any video games. There are relatively few research studies that investigate the effects that violent video games have on cognitive performance, and even fewer studies which have compared violent to non-violent video games.

Overall, the main finding from the current research is that there were different trends in the data based on the condition. First, those in the control condition did not show any change in their SynWin scores, from time 4 to time 5, which suggests that the filler task they completed was complex and cognitively engaging enough to stabilize their cognitive skills. Second, those in the violent video game condition had a significant increase in cognitive performance, from time 4 to time 5. This suggests that the stimuli and amount of cognitive resources necessary to complete the game was sufficient enough to affect the SynWin scores. Finally, those in the non-violent video game condition also had an increase in SynWin scores from time 4 to time 5. Similar to the violent video game condition, this suggests that the non-violent video games were sufficient enough to enhance cognitive performance. These last two findings are important because two implications can be drawn. The first is that these findings suggest that any video game that is stimulating and requires a certain amount of cognitive energy to complete will increase cognitive performance. This finding has applied implications, because certain corporations, such as the FAA, are allowing employees to play video games to cognitively "warm-up." The second implication is that these findings suggest that the cognitive benefit from playing video games occurs independently of content. Thus, violent video games are not the only video games that are able to increase cognitive performance. We believe that such findings warrants future research, which takes into account more control variables, such as participants ratings of how stimulating, fun, frustrating, and so forth the video game is perceived to be. Another area of future research would be to determine if the increased cognitive skills, ascertained from video game play, transfers to real life problem-solving tasks.

This research adds to the existing literature on video games and cognition in three ways. First, there has only been one other published study that has examined cognitive performance using SynWin with a violent computer game (Kearney, 2005). This study replicated the findings from Kearney (2005), while addressing various limitations of that study. Specifically, the current study made sure that any change in the SynWin scores was not a function of practice, as could be argued in the Kearney study. Second, frequent video gamers were not sampled, and hence, these findings can be related to a more general population. Third, the distributional properties and the inter-correlations between SynWin trials were analyzed, which was not done in prior studies.

Theoretically, these results have implications for the transfer of cognitive skills from one task to another. The results show that those who did not play a video game, compared to those that did play either a violent or non-violent video games, had no change in cognitive performance. It is speculated that the findings occurred because those who played the video games were able to retain and enhance their skills necessary for cognitive functioning. Those in the control condition did not have, a task that enhanced such skills, but rather a task that maintained their cognitive abilities.

These results have implications for those in society who are concerned with computer game play and computer game training. These results suggest, overall; that playing computer games may significantly increase cognitive performance. Although playing a violent video game may lead to increases in aggression and arousal, as shown in past research (see Anderson, 2004), video games can also increase cognitive performance, as shown in the current study and past research (e.g., Kearney, 2005). This generalization needs to be interpreted with caution because aggression, hostility, and physiological arousal were not measured in the current research studies. Thus, the results of the current study do not suggest that playing violent video games is good, because although we know that violent games may increase certain short-term cognitive variables (such as attention Green & Bavelier, 2003 and general cognitive abilities Kearney, 2005; results from this study), but violent video games also increase short-term aggressive thoughts, aggressive feelings, and aggressive behavior (see Anderson, 2004).

A distinct feature of this research is the use of the program SynWin, to assess cognitive performance. This has important advantages because the SynWin scores reveal no significant difference between those who played a non-violent and a violent video game. This is an interesting finding because it reveals that the increases in cognitive performance are independent of the violent content of the video game. Research conducted in this area has not previously compared the differences between violent and non-violent video games.

There are three main strengths of this research. First, all participants, independent of condition, reached asymptotic behavior on SynWin prior to engaging in their computer task (either a computer game or an internet search). This is a strength because this procedure allowed for any conclusions to be drawn to be attributed to the condition, and not by practice effects, like in the Kearney (2005) study. The second strength of this study is that participants in the control group worked on a computer, but not playing any computer game, thus not enabling as many cognitive processes as those in the experimental conditions. The final strength of this study is that SynWin was used as a measure of cognitive processes. Unlike the studies by Bliss et al. (1991), Colom et al. (2003), more than one cognitive variable was evaluated at a time.

The present studies do have limitations. The first limitation is that the current study may have compared non-equivalent violent and non-violent video games to one another. These games may not be equivalent in a number of possible mediating variables (besides content), such as: the amount of action, the amount of concentration necessary to play these games, and how interesting or fun the games are to play. Future research should ask participants to rate the games on similar dimensions after playing them and treat any differences as covariates in the primary analyses. Second, performance was not measured on any of the computer games. Performance could not be measured on certain computer games, such as the tile game and Red Alert 2; because scoring is only reported after the entire computer game is played. Eighteen minutes was not enough time for participants to finish some of the games, and hence, performance scores were not measured. Future research should use games that would allow for performance to be accurately measured, within the time limits allowed.

Overall, the findings from the study support the thesis that video games can affect short-term cognitive performance. The results suggest that the non-violent and violent video games both significantly increased general cognition. Those in the control condition did not have any change in their cognitive performance from time 4 to time 5. These findings have implications for society who are concerned with video game effects, as it suggests that cognitive benefits from video games are not dependent upon content, as non-violent video games are related to cognitive gain.

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