

Background Music Matters: Why Strategy Video Game Increased Cognitive Control

Jiulin Zhang* and Xiaoqing Fu

School of Psychology, Southwest University, Chongqing-400700, China

Abstract

For decades, the precise influence of video games on players has been acutely argued. During that time, researchers have also been unable to agree on the effects that video games have on cognitive control. Some researchers found that video games are detrimental to sustaining one's attention span, working memory, and cognitive flexibility. Meanwhile, some other researchers have claimed that video games have a positive effect on visuospatial cognition, executive control functions, and cognitive improvement. To discover the hidden factors that cause such inconsistent results in this field while investigating the influence that video games have on one's cognitive control in a more subtle way, this study strictly controlled the game genre, the measure of one's cognitive control, and the background music in video games.

In this study, 45 participants were randomly assigned to three groups: a control group, which required participants to use the internet to search for information related to a certain subject; a no-music game group, which required participants to play a strategy game (Command and Conquer: Red Alert 2) without earphones; and a music game group, which required participants to play the same game but with earphones to enjoy the game's background music. All of these conditions lasted for 20 min. Before the formal experiment, all participants were asked to finish an N-back task, and their performances were used as covariates in the final analysis. After the experiment, participants were also asked to complete a color-Stroop task, and the results served as the index of their cognitive control ability. The results showed that the no-music video game can significantly improve players' reactive control. Compared to the control group and the no-music video game group, the music video game significantly benefited the participants' proactive control. This study indicates that when the strategy video game is played without background music, the reactive cognitive control is improved as demonstrated by other video games. The background music appears to make the strategy video game more strategic, which significantly increases proactive cognitive control ability. These results show that background music does play a crucial role in the influence of video games.

Keywords: Strategy video game; Background music; Reactive cognitive control; Proactive cognitive control

Introduction

According to the "29th Statistical Report on Internet Development in China" issued by the CNNIC, by the end of 2011, the number of online video game players (gamers) in China had reached 324 billion, with a growing rate at 6.6%. Population-based samples indicate that average gaming time ranges from 7 to 13 h per week in children and adolescents. Playing video games has become the most popular form of entertainment for children and adolescents (Gross, 2010). The popularity of video games highlights the need for research into the possible effects of playing video games.

Much of the research on video games so far has mainly focused on its negative effects, namely, addiction [1-3] and aggression [4-6] due to game violence. There are now many studies that have explored what is being called "pathological gaming" or "video game addiction". Many researchers have defined the pathological use of video games as pathological gambling, choosing to focus on the damage to family, school, occupational, and psychological functions [7]. Many other researchers have concentrated their efforts on the influence of violent video games on players in terms of aggressive behavior [5,6]. Findings of experimental, correlational, and longitudinal studies have claimed that video game violence can significantly increase aggressive thoughts, emotions, and behavior over both the short term and the long term [8,9]. In addition, a significant body of literature also has indicated that playing violent video games can exacerbate attention problems [10], produce desensitization to violence, decrease empathy [11], and assist in decreasing school performance [8].

In recent years, scientists increasingly have begun to examine the

potential to use this immensely popular media for positive purposes [12]. Some research has shown that video games can improve a wide range of visual and spatial skills [13] and can be a highly effective tool for teachers [14]. Moreover, prosocial video games have been proven to promote related prosocial behaviors [15]. There is a tendency to claim that the negative effects of video games have been exaggerated in the past, and it is now a good time to examine whether video games may be put to some good use [12].

Among such claims, the relationship between cognitive control and video game playing has gained a lot of attention. In particular, Kronenberger et al. [16] found a negative correlation between playing video games and performance on the color-word Stroop task for both adolescents with behavior disorders and controls [16] found that individuals with higher media violence exposure showed less activation in the anterior cingulate cortex and inferior frontal gyrus, which may indicate a failure to recruit cognitive control networks during performance of the Stroop task. In addition, Swing [17] reported a positive correlation between video game experience and a composite

*Corresponding author: Jiulin Zhang, School of Psychology, Southwest University, Chongqing-400700, China, Tel: +86-23-68250773; E-mail: 65725008@qq.com

Received February 01, 2015; Accepted April 13, 2015; Published April 15, 2015

Citation: Zhang J, Fu X (2015) Background Music Matters: Why Strategy Video Game Increased Cognitive Control. J Biomusic Eng 3: 105. doi:10.4172/2090-2719.1000105

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index of symptoms related to attention deficits and hyperactivity. This kind of phenomenon revealed a unique effect of video games on self-reported levels of attentional impairments.

On the contrary, immense amounts of concrete research achieved the opposite result [18] found that gamers exhibited superior visual performance on a variety of attention-demanding tasks, including spatial target localization, rapid target identification, and multi-object tracking. Gamers may have greater control over task switching in addition to better temporal attentional processing [19,20] suggested that gamers may benefit from a higher-level executive control ability, allowing for more efficient control and allocation of selective attention. What's more, Bailey [21] found that violent gamers appeared to have a greater span of apprehension and visual short-term memory capacity compared to non-gamers and nonviolent gamers. This improvement can be observed with as little as 10 h of video game training [22,23].

Several factors may account for these inconsistent results in this field. First, the measure of cognitive control ability is not unified. Some researchers believe that the cognitive control can be divided into several minor elements and measured separately. Therefore, many researchers have tried to study the ability of cognitive control on the basis of each component, such as attention allocation and switch ability [19,24-27] executive functions [20,28] visuospatial processing [24,29] cognitive flexibility [30] and decision-making [31]. However, some other researchers have conducted their research about the influence of video games on the ability of cognitive control based on the proactive or reactive modes of cognitive control from the theory on dual mechanisms of cognitive control (DMCC) [9,5,21]. The diverse focus on one's cognitive control ability would concededly lead to divergent results.

Second, the video games used in research are diverse in genres Caldwell [32] once claimed that one crucial problem that existed in the study of video games is that they cannot be regarded as a consistent medium. Taken as a whole, the field of video games can hardly be considered as uniform or consistent [33]. In view of this, different researchers have deployed different types of video games when examining its influence on the ability of cognitive control. These include violent video games [20], action video games [25,27], strategy video games [21,28] and first-person shooter games [18,24,30]. Different genres of games, even different subgenres of games, deploy diverse abilities [32]. It is no doubt that results appeared different or even completely opposite from the experiments conducted.

Another neglected factor that could cause distinct results may be background music. Although we usually call computer games as "video games", the audio also plays an important part in video games [34-36] concluded that music in video games can serve to "enhance a sense of immersion, cue narrative or plot changes, act as an emotional signifier, enhance the sense of aesthetic continuity, and cultivate the thematic unity of a video game". Games are becoming more reliant on music since they have an important role to play in supporting user interaction with the game environment [34]. Different immersive states in video games directly had different effects on the influence of video games content on the players [37]. However, previous researchers have seldom considered this important uncertainty in their experiments. Therefore, it is necessary to see whether players will behave differently when they are involved in different attractive video games.

Present Study

To determine the hidden factors that caused inconsistent results when exploring the effects of video games on cognitive control ability,

we conducted research on the basis of three possible confusion variables mentioned above.

In this study, three groups of participants were randomly chosen. Before gameplay, all of them were required to finish an N-back task. Then, one group was treated as the control group and asked to use the internet on a computer for 20 min to search for information related to air traffic controllers. Another group was asked to play a kind of strategy video game (*Command & Conquer: Red Alert 2*) but without earphones for 20 min. The last group was asked the same as the previous group except they were required to wear earphones during the gameplay to enjoy the game's background music. After finishing this procedure, they were asked to finish a classic color-Stroop task. Their performance in the Stroop task served as the index of their cognitive control ability.

A control group was used in order to make the results more convincing. The participants in the control group worked on a computer, but they did not play any computer games. This prevented them from enabling as many cognitive processes as those in experimental conditions. In addition, this also allowed all conclusions drawn from this experiment to be attributed to such conditions and not by practice effects [5].

The strategy video game was employed in this study because it would exert a special effect on one's cognitive control ability. Most studies on the perceptual effects of video games in recent years have utilized a particular genre, that of the fast-action first-person shooter (FPS). However, it is misleading to base conclusions about video games in general on a single genre. These results underline the importance of studying the cognitive and perceptual consequences of video games in terms of the types of skills demanded from a particular video game [38,39]. Just as discussed above, different video game genres would have a different influence on one's cognitive control ability [19,24,25]. First-person video games may specifically increase individuals' ability to deploy selective attention, but not their ability to resist proactive interference from prior situations. Experience and training in demanding high-interference video games might result in a different set of abilities than in action video games [19].

Compared to other video games, the strategy video game has its own features. It is different from other genres of video games that emphasize the ongoing play of contextualization [33]. The strategy video game requires the constant attention and performance of the player, and those that require a more distant approach characterized by intervention [19]. The player has to manipulate the simulation as it progresses through time in order to get the result with the most utility. Therefore, this may involve long periods of surveillance, where the player makes no direct interventions [33]. That is to say, the players in strategy video games cannot even lower their guard for a moment until they finished the whole game. They have to constantly perform kinesthetic actions, manipulate the controller, and follow the visual cues supplied by the screen [33]. This highly and persistently concentrated mind state will inevitably exert a much more significant influence on cognitive control ability, especially on proactive control ability [9,28].

The Stroop task was used in the present study as a measure of the proactive and reactive cognitive control ability based on the DMCC theory [28]. This theory holds that individuals can engage in either proactive or reactive modes of cognitive control depending on environmental demands and individual differences [39]. Proactive control relies upon the anticipation and prevention of interference before it occurs, whereas reactive control relies upon the detection

and resolution of interference after its onset [40]. Since strategy video games are characterized as a constant engagement with overwhelming amounts of information, they create a constant cascade of cognitive shocks that require immediate responses [33]. Thus, it is justified to assume that a strategy video game would generate a more significant effect on proactive cognitive control than on reactive control.

Anecdotal evidence [9,41] suggest that the classic color-Stroop task is a sensitive and valid way to separately measure the proactive and reactive control ability. For the results of the Stroop task, the conflict adaptation effect serves as an index of proactive control [42]. This effect represents the difference in response time for an incongruent trial when that trial is preceded by a congruent trial or an incongruent trial (i.e. subtracting the response time of incongruent-incongruent trials from the response time of congruent-incongruent trials). Reactive control is measured by the Stroop interference effect [39].

Finally, the two experiment groups (one with earphones and the other without) were used in this research mainly for investigating the role of players' subjective immersion in the influence of strategy video game on cognitive control. Immersion is one aspect of the experience of playing video games and is widely held to be critical to the overall success of a video game [43]. It is likely that most regular gamers have experienced some degree of immersion [44]. Immersion could increase or decrease the carryover effects of game content into real-world outcomes as a function of need satisfaction. Moreover, it can serve as a key moderating variable that amplifies the effects of virtual content on actual goals and decision making [45].

Background music plays a significant role in the immersive quality of a video game [35]. It may give players the impression of a realistic space by presenting virtual off-screen sources [46] claimed that video games use background music to provide an audio complement for the action on the screen and to create a sense of real physical space. All sounds in the video game contribute in some way to player immersion in the acoustic ecology [47]. By tightly linking game play and music, the player can become much more immersed in the experience [48]. Therefore, in this study, the two experiment groups, which shared the same game content but differed in whether or not background music appeared, were employed with the purpose of testing the influence of background music on cognitive control through its influence on players' subjective immersion.

Methods and Materials

Participants

Through advertisements on the campus network, 45 male college students were recruited. The candidates were selected based on the following requirements:

- 1.) Candidate has familiarity with Command & Conquer: Red Alert 2;
- 2.) Candidate is right handed; and
- 3.) Candidate has normal hearing ability.

The average age for this sample was 20.78 yr (SD = 1.63 yr). The average video game play during a weekday was 1.43 h (SD = 1.02 h), and the average video game play during the weekend was 2.63 h (SD = 1.79 h). In addition, the three groups did not significantly differ in whole play time each week, $F(2,37) = 1.44$, $P = 0.25$.

Materials

Game experience questionnaire: The participants' game experience was measured by a scale designed by Anderson and Dill

[49]. Participants were asked to list their three (3) favorite video games, and rate how violent and how often they played that game each week. The total score was the index of the participants' game experience and used as covariates in the final analysis.

Strategy video game: The game that was used in this study was a classic strategy video game - Command & Conquer: Red Alert 2 (known as Red Alert 2), which was developed by Westwood Pacific (associated with Westwood Studios). The purpose of this video game is to build a military base to defend our own base from enemy attacks, and destroy the opposing army's troops and base. Participants were required to earn more "money" and spend it on a number of buildings (e.g. barracks, satellites, and war factories), many vehicles (e.g. tanks, fighter planes, and helicopters), and troops (e.g. basic infantry, engineers, and attack dogs).

Red Alert 2 is a real-time strategy game that combines both the speed of real-time gaming and the complexity of turn-based strategy games. One of the important aspects of this game is that it allows for multiple ways to achieve victory. In this game, the player continually has to assess available resources, plan and expend those resources, and utilize expanding territories and multiple cities rationally to achieve final success.

Another important reason that Red Alert 2 was employed was that the background music played a crucial role during the whole game. The realistic and stirring background music that accompanied the dramatic plot would cause the players to become more involved in the game environment.

N-back task: Participants in this task are shown a list of stimuli (e.g. letters or numbers) one at a time and must judge whether or not each stimulus matches the one directly before it (1-back condition), or prior to the one before it (2-back condition), or two stimuli before it (3-back condition). The accuracy in the task is a manipulation of cognitive control [21].

In this study, an N-back task stimuli consisted of 26 letters (A-Z) randomly presented on a white background. Participants performed a practice block of 25 trials each for the 1-back and 2-back conditions. In the 1-back condition, participants should judge whether each letter matched the previous letter. In the 2-back condition, they were told to judge whether each letter was the same or different from the letter before the previous letter. There were two experimental blocks consisting of 20 targets and 30 non-targets for a total of 50 trials in each block.

Stroop task: A classical color Stroop task was employed in this research. In this paradigm, word stimuli consisted of a random presentation of three color names (red, green, or yellow) presented in one of these three colors. In the congruent condition, the color in which the word was presented matched the color name (e.g. the word "green" displayed in green). In the incongruent condition, the color of the word presented did not match the color name (e.g. the word "green" displayed in red). The participants in this task were told just to make judgments according to the color of the words while ignoring the color name. The test phase consisted of two blocks of 80 trials. In each block there were 40 congruent and 40 incongruent stimuli.

Procedure

All participants who entered the laboratory were requested to finish a game experience questionnaire. Upon completion, they should finish the N-back task. Then, all participants were randomly assigned to three

groups: the control group (n = 15), the music game group (n = 15), and the no-music game group (n = 15). Participants in the control condition used the internet to search for information about air traffic controllers for 20 min. This filler task was used in order to keep the participant's hand-eye coordination constant. Participants in the no-music game experimental condition played Red Alert 2 for 20 min quietly without earphones. Participants in the music-game experimental condition also played Red Alert 2 for 20 min but with earphones in order to enjoy the background music that accompanied the game content. After 20 min, all participants completed the color-Stroop task. All participants were then thanked and fully debriefed.

Results

Game experience

A one-way ANOVA was conducted to examine whether the participants' game experience was significantly different from each other among the three groups. Results showed that the participants' game experience was not significantly different from each group, $F(2,42) = 1.44, P = 0.25 > 0.05$. This means that the game experience was not a significant contributor to the final results in this study.

Reactive control

Response time was slower for incongruent trials, with $M = 731.06$ ms ($SD = 73.99$ ms), than congruent trials, with $M = 638.67$ ms ($SD = 80.81$ ms), revealing a significant interference effect, $t(44) = 66.28, p < 0.001$. Then, a MANCOVA was conducted with the difference in response time in the Stroop task between the incongruent trials and congruent trials (i.e. subtracting the response time of incongruent trials from the response time of congruent trials) as the dependent variable, the group as the independent variable, and the response time in the N-back task as the covariate. Results showed a significant main effect for group, $F(2, 42) = 3.69, P < 0.05$. A follow-up analysis was conducted, and the results showed that only a significant difference existed between the control group and the no-music game group, $P = 0.032, M(\text{control}) = 54.93$ ms, $M(\text{no music}) = 114.29$ ms. No other significant differences were found. In other words, the no-music strategy video game significantly improved the players' reactive cognitive control ability compared to the control group.

Proactive control

To examine the influence of experiment conditions on proactive controls, a MANCOVA was conducted with the conflict adaptation effect (i.e. subtracting the response time of incongruent-incongruent trials from congruent-incongruent trials that were non-repetitious) as the dependent variable. The experimental condition and the N-back scores were separately used as an independent variable and a covariate, respectively. Results showed a significant main effect for the group, $F(2, 42) = 4.87, P < 0.05$. Upon further examination, it appeared that there were significant differences between the music game group and the no-music game group, $P = 0.02$, and between the music game group and the control group, $P = 0.04, M(\text{control}) = 153.50$ ms, $M(\text{no music}) = 165.94$ ms, $M(\text{music}) = 31.08$ ms. In other words, the strategy video game with background music significantly improved the players' proactive cognitive control ability (Tables 1 and 2).

Discussion

To determine the hidden factors that cause arguments the influence of video games on cognitive control, this study made some subtle controls on the possible factors that could exert effects on the final

results. In this research, we insisted that those vibrant "factors" were included in the following three aspects: distinct in measuring cognitive control, diverse in game genres, and accompanied by background music.

In terms of measuring cognitive control, based on the DMCC theory [28] this study employed a classic color-Stroop task to test separately the influence of video games on the proactive and reactive cognitive control. The video game used in this research was Red Alert 2, a classic kind of strategy video game. As some research has demonstrated that different video game genres would exert different effects on cognitive control [19,24,25] the strategy video game, was selected due to its specific characters, which may have peculiar effects on the proactive and reactive cognitive control [19,33]. A large amount of previous research showed that background music plays a significant role in the immersive quality of a video game [35]. Thus, in this study, one group was employed to hear background music while the other was not. This was in order to detect the role of subjective immersion in relation to the influence of video games on one's cognitive control.

The results showed that the no-music strategy video game can significantly improve the players' reactive cognitive control compared to the control group. Moreover, the strategy video game with background music can significantly improve the players' proactive cognitive control ability compared to both the control group and the video game group without background music.

On one hand, the results indicated that the strategy video games without background music just exerted the same effect as other kinds of video games: a significant improvement of the reactive cognitive control. Theoretically, owing to its characteristics, the strategy video game should significantly improve the proactive cognitive control [9,28]. However, when the video game was played without background music, which caused the video game to become less fascinating and attractive, the players in this kind of situation would become less immersive into the game environment and plot. As a result, they unlikely made a thorough plan for fear of the enemy's unexpected attack. On the contrary, they preferred to counterattack after the enemy appeared within the visible area, which were almost the same as other kinds of video games (i.e. action games and role-playing game). These kinds of video games required players to respond as soon as possible according to the stimuli that appeared on the screen [50]. They also encouraged players to quickly modify their behavior when experiencing conflict (i.e. encountering an enemy). This attribute of the video game suggested that high gamers were less likely to employ proactive controls and more likely to employ reactive controls [9]. For example, Bailey [21] found that violent video games encouraged and

Item	Incongruent trials (ms)		Congruent trials (ms)	
	M	SD	M	SD
Control group	746.1	71.22	681.17	106.93
Without-music group	763.02	54.45	-	47.4
With-music group	684.06	73.94	607.99	61.23

Table 1: Means and standard deviations of response time in Stroop task.

Item	Incongruent trials (ms)		Congruent trials (ms)	
	M	SD	M	SD
Control group	669.35	80.32	822.85	77.35
Without-music group	680.06	68.78	845.99	92.51
With-music group	668.52	78.8	699.6	144.1

Table 2: Means and standard deviations of response time of incongruent trials in Stroop task.

enhanced the use of reactive controls, so players may employ reactive controls more efficiently than non-gamers. The result of this research showed that strategy video games, if played without background music, had a similar impact on cognitive control as other kinds of video games that have been widely discussed in numerous studies [19,24,25].

On the other hand, the result of this research also demonstrated that the background music caused the strategy video game to become a real “strategy” video game. We can conclude that background music plays a significant role in the immersive quality of a video game [35]. In addition, music is often used in video games to provide an audio complement for the action on the screen and to create a sense of a real physical space [46]. The player can become much more immersed in the experience when the video game is linked with related background music [48]. In the present study, when the strategy video game was played with its own background music, the players became much more immersed into the game content. Therefore, at the beginning of the game, the players would make a comprehensive plan for the whole round. Due to the special features of the strategy video game, the players tended to manipulate the operation as it progressed through time in order to get the result with the most utility. Meanwhile, they never lowered their guard until they finished the whole game. This highly and persistently concentrated mind state will inevitably exert a much more significant influence on cognitive control ability, especially on the proactive control ability [9,28].

The results basically supported the initial hypothesis. The background music does exert an influence on players’ cognitive control ability by changing players’ immersion state. Background music improves the narrative experience and can be used to guide the player through the game [51,52] claimed that music may encourage immersion, which must complement the gamer’s engagement with the game’s scripts. Some researchers achieved similar results [47,53]. All of these results show the indispensable role of background music in video games.

Video games are one of the fastest growing forms of entertainment. With competition in the industry increasing, designing video games to be as enjoyable and entertaining as possible becomes a central goal for game developers [54]. Music and sound are often important expressional elements used in various forms of computer-based entertainment [55]. The audiovisual can be seen as prerequisites for gameplay immersion and rewarding gameplay experiences [56]. Thus, using music and adaptive audio to support immersion may be one way of enhancing the quality of video games as well as making video games more popular media.

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