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index of symptoms related to attention deficits and hyperactivity. We conducted research on the basis of three possible confusion variables. The 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 achievements. Before gameplay, all of them were required to finish an N-back task. The opposite result [18] found that gamers exhibited superior visual performance on a variety of attention-demanding tasks, including internet on a computer for 20 min to search for information related to spatial target localization, rapid target identification, and multi-object tracking. Gamers may have greater control over task switching in air traffic controllers. Another group was asked to play a kind of strategy video game (Command & Conquer: Red Alert 2) but without 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 greater span of apprehension and visual short-term memory capacity compared to non-gamers and nonviolent gamers. This improvement control ability can be observed with as little as 10 h of video game training [22,23].

Several factors may account for these inconsistent results in the 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 genre. 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]. Compared to other video games, the strategy video game has its own features. It is different from other genres of video games that diverse abilities [32]. It is no doubt that results appeared different 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].

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]. It 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.

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. The kind of phenomenon revealed a unique effect of video games on self-reported levels of attentional impairments.

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

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. A color Stroop 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.

Reaction Time

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, $M(\text{music}) = 131.08$ 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, the no-music group was employed to hear background music while the other two groups were 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 no-music 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 [19,28]. However, when the video game was played without background music, which caused the video game to become less fascinating and less attractive, the players in this kind of situation would become less immersed into the game environment and plot. As a result, they should significantly improve their proactive cognitive control ability.

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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