Psychology of Popular Media Culture

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Cognitive Abilities of Action Video Game and Role-Playing Video Game Players: Data From a Massive Open Online Course

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Numerous studies have demonstrated that regularly playing action video games (AVGPs) is associated with increased cognitive performance. Individuals who play role-playing video games (RPGs) have usually been excluded from these studies. This is because RPGs traditionally contained no action components and were thus not expected to influence cognitive performance. However, modern RPGs increasingly include numerous action-like components. We therefore examined whether current RPG players (RPGPs) perform similar to action video game players (AVGPs) or nonvideo game players (NVGPs) on two cognitive tasks. Self-identified AVGPs (N = 76), NVGPs (N = 77), and RPGPs (N = 23) completed two online cognitive tasks: A useful field of view (UFOV) task and a multiple-object tracking task (MOT). The UFOV task measures the ability to deploy visuospatial attention over a large field of view while dividing one's attention between a central and a peripheral task. The MOT task measures the ability to use attentional control to dynamically refresh information in working memory. RPGPs performed similar to AVGPs and better than NVGPs on both tasks. However, patterns of covariation (e.g., gender and age) presented obstacles to interpretation in some cases. Our study is the first to demonstrate that RPGPs show similar cognitive performance to AVGPs. These findings suggest that regularly playing modern RPGs may enhance visuospatial abilities. However, because the current study was purely cross-sectional, intervention studies will be needed to assess causation. We discuss the implications of this finding, as well as considerations for how gamers are classified going forward.

Public Policy Relevance Statement

We investigate whether individuals who play action video games that are mostly first- or third-person shooter games, as well as individuals who play action role-playing games, differ in their cognitive abilities as compared with nonvideo game players. We demonstrate that both action and role-playing gamers outperform nongamers on two attentionally demanding tasks and perform similarly to each other, suggesting that games other than those traditionally placed in the "action" genre may be beneficial for cognitive performance.

Keywords: action video games, real-time strategy video games, role-playing video games, useful field of view, multiple object tracking

The vast majority of commercial video games, from the very earliest examples of the medium, have primarily been designed with entertainment-based goals in mind—that is, to be fun and enjoyable to play. However, psychologists quickly realized that the characteristics of many video games made them potentially powerful tools to produce meaningful changes in perceptual, attentional, and/or motor functions. Seminal work by Griffith and colleagues in the early 1980s first put forth the argument that video

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games are more than simply mindless entertainment (Griffith, Voloschin, Gibb, & Bailey, 1983). Instead, it was hypothesized that certain features inherent to video games could make them excellent activities for developing both visuomotor and cognitive skills. This same theme was continued in the 1990s by Greenfield and colleagues, as well as a host of other labs. Over this period a great deal of empirical evidence accrued showing the capacity of video games to alter functions as varied as divided attention, mental rotation, speed of processing, hand–eye coordination, and spatial attention (Dorval & Pépin, 1986; Gagnon, 1985; Greenfield, Brannon, & Lohr, 1994; Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994; Okagaki & Frensch, 1994; Subrahmanyam & Greenfield, 1994).

Notably, the abovementioned work tended to either examine the impact of specific individual games (i.e., to look at the effects of training on one specific game) or else consider all games together (i.e., to use the total amount of video gaming as the measure of interest). However, as the video game industry developed and grew through the late 1990s, a number of reasonably distinct video game genres, or categories, emerged. Games belonging to a given genre were linked by a number of commonalities inherent in their gameplay. For instance, individual games belonging to the turn-based strategy game (TBS) genre differed from one another in myriad ways, but they nonetheless tended to share a number of critical features. In this case, those characteristics are given by the name. TBS games are those that are focused on strategy. They involve careful consideration/decision-making in a well-defined tree-structure environment, where each decision opens up new possibilities for both the player and their opponents to consider. They are also turn based. In other words, players take turns making moves, with each move being fully executed before the opposing player(s) can make a move in response.

The development of such genres allowed for a methodological approach that lies between examining the impact of an individual game and considering all games together. Because games in a genre, by definition, share a set of critical characteristics, researchers could examine the impact of specific genres of video games. It was during this period that one particular genre of video game—what has been dubbed the "action video game" genre—began to particularly interest research psychologists (Chisholm & Kingstone, 2012; Colzato, van den Wildenberg, Zmigrod, & Hommel, 2013; Feng, Spence, & Pratt, 2007; Green & Bavelier, 2003, 2006; Strobach, Frensch, & Schubert, 2012; Wu & Spence, 2013). Although there are no quantitatively defined rules that delineate games as members of the action genre, action games have generally been defined as those games that place substantial load upon perceptual, attentional, and cognitive systems by requiring participants to attend to multiple pieces of complex and rapidly changing information across a broad visual field and that require fast and accurate responses to these stimuli. To perform successfully on many of these games, participants must possess good visuospatial attention, working memory capabilities, object-tracking skills, and inhibitory control (Green & Bavelier, 2012; Spence & Feng, 2010). The action game genre has historically been composed of games from a number of distinct subgenres including the first-and the third-person shooter subgenres. Games from both subgenres share the characteristics noted earlier and differ primarily in the viewpoint of the player (first-person shooter = looking directly through the character's eyes; third-person shooter = looking at the back and/or top of the character).

Given the demanding nature of these games, Green and Bavelier (2003) hypothesized that regular players of action games would show enhanced performance in certain perceptual and cognitive functions as compared with individuals who did not regularly play games from the action genre (i.e., that there would be a correlational/cross-sectional effect of action game experience). Furthermore, they proposed that specifically training individuals who did not normally play video games by having them play action games for many hours over the course of several weeks would result in increased performance as compared with individuals who were trained for the same period of time on a nonaction video game. In other words, it was hypothesized that a causal link could be drawn between the act of playing action video games and augmented perceptual/attention/cognitive performance. Consistent with these hypotheses, Green and Bavelier (2003) demonstrated that action video game players (AVGPs) performed better than nonvideo game players (NVGPs) on the useful field of view (UFOV) task, the attentional blink task, and a visual enumeration task. These tasks measure the deployment of visuospatial attention under divided attention, the temporal characteristics of attention allocation, and short-term memory capacity, respectively (Green & Bavelier, 2003). The same basic effects were then found in a true experiment in which NVGP individuals trained on an action video game showed significantly larger improvements in performance on the abovementioned tasks after training as compared with NVGP individuals trained on a nonaction video game (Green & Bavelier, 2003). Since then, researchers from many different groups worldwide have observed results in the same direction utilizing both cross-sectional and true experiment designs on a variety of tasks including (but not limited to) multiple-object tracking (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Green & Bavelier, 2006; Sungur & Boduroglu, 2012; Trick, Jaspers-Fayer, & Sethi, 2005), visual search (Castel, Pratt, & Drummond, 2005; Hubert-Wallander, Green, Sugarman, & Bavelier, 2011; Wu & Spence, 2013), oculomotor capture (Chisholm, Hickey, Theeuwes, & Kingstone, 2010; Chisholm & Kingstone, 2012, 2015a, 2015b), task switching (Boot et al., 2008; Cain, Landau, & Shimamura, 2012; Chiappe, Conger, Liao, Caldwell, & Vu, 2013; Colzato, van Leeuwen, van den Wildenberg, & Hommel, 2010; Green, Sugarman, Medford, Klobusicky, & Bavelier, 2012; Karle, Watter, & Shedden, 2010; Strobach et al., 2012), attentional blink (Green & Bavelier, 2003; Oei & Patterson, 2015), multitasking/dual-tasking (Strobach et al., 2012), mental rotation (Feng et al., 2007), visual short-term memory (Blacker & Curby, 2013; Blacker, Curby, Klobusicky, & Chein, 2014; Boot et al., 2008; Colzato, van den Wildenberg, & Hommel, 2014; Li et al., 2015; McDermott, Bavelier, & Green, 2014; Wilms, Petersen, & Vangkilde, 2013), and the Attention Network Test (Dye, Green, & Bavelier, 2009; Wilms et al., 2013).

Not all studies have replicated the positive effects of action gaming (Boot et al., 2008; Castel et al., 2005; Murphy & Spencer, 2009; van Ravenzwaaij, Boekel, Forstmann, Ratcliff, & Wagenmakers, 2014). Furthermore, the evidence is mixed for whether or not playing action games influences certain cognitive abilities such as exogenous attentional orienting (Castel et al., 2005; Dye et al., 2009; Hubert-Wallander et al., 2011), or some aspects of working memory (Boot et al., 2008; McDermott et al., 2014). However, when the literature is viewed together, the evidence suggests that consistently playing action video games is associated with enhancements in a variety of cognitive abilities—a proposition confirmed by recent meta-analyses of the field (Bediou, Adams, Mayer, Green, & Bavelier, 2018; Powers & Brooks, 2014; Powers, Brooks, Aldrich, Palladino, & Alfieri, 2013; Sala, Tatlidil, & Gobet, 2018; Toril, Reales, & Ballesteros, 2014; Wang et al., 2016).

Like all forms of media, the video game medium has continued to grow and change over time (Dale & Green, 2017b; Spence & Feng, 2010). One key change that has occurred since the earliest work by Green and Bavelier is that a number of games and game genres that previously contained little-to-no "action" content now include moderate-to-substantial degrees of action-like characteristics. The hypothesis that action video game play enhances perception, attention, and cognition because of certain core action mechanics such as (a) making decisions under time pressure, (b) putting a constant load on divided attention, and (c) requiring timely shifts between two different attentional states (a focused and a divided one) in turn predicts that if a video game genre evolves to integrate such action mechanics, it should likewise be observed to positively impact cognition. This study tests this hypothesis by considering the cognitive impact of the role-playing game (RPG) genre.

The RPG genre has undergone major shifts over the past several decades with a dramatic increase in action-like content. Traditional RPGs typically contained little-to-no action characteristics and instead heavily focused on a storyline that was at least partially driven by well-defined quests and dialogue trees. RPGs emphasized exploration and searching to gather special items and experience points to develop the player's character. Furthermore, classic role-playing games used turn-based action mechanics. For example, Final Fantasy VII, released in 1997 and one of the most popular video games of all time, was completely turn based, meaning that the player could spend as much time as they desired in choosing and executing actions. Because of this, classic RPG gameplay focused more on strategy rather than rapid decision-making. Today, however, the most recent titles from the Final Fantasy series present stimuli in real time, are highly intricate, and often require the same basic techniques and attentional abilities as action games (Dale & Green, 2017b). Indeed, it is becoming increasingly rare to find an RPG game that contains few action components.

Concomitant with this evolution in the RPG genre has come the rise of what has become known as the action-RPG hybrid genre. As the name suggests, this RPG subgenre combines the role-playing elements of the RPG genre with the action elements inherent in first-person/third-person shooters. For example, if a casual observer happened upon an individual playing an action-RPG hybrid while the player's character was conversing with nonplayer characters, the game may look indistinguishable from a classic RPG. If, however, the same observer happened upon an individual playing an action-RPG hybrid while the player was in combat, the game may look indistinguishable from a pure third-person shooter (Figure 1; Dale & Green, 2017b). Given these substantial changes in the RPG genre, it may be expected that RPGs will impact cognition very similarly to AVGs.

In support of this hypothesis, researchers have already begun to show that playing games from another traditionally nonaction genre—the strategy genre—is associated with differences in cognitive performance that are similar to those found with playing classic AVGs. Strategy games typically focus the strategic movement of units or armies across a map to capture land and resources or to defeat other units or armies. Early strategy games were predominantly turn based, such that the player and opponent(s) took turns moving their units across the map, and there were no time limits during a turn (these are the TBS games mentioned earlier; Civilization, 1991). Because of this, strategy games from this period were slow-paced and placed few demands on the speeded allocation of attentional resources. As such, they could reasonably be classified as nonaction games (Dale & Green, 2017b). However, over time, the strategy genre has come to include an ever-growing number of games played in real time, where the player and opponent(s) move their units simultaneously without the luxury of having unlimited or lengthy time limits in which to decide on their next move (e.g., StarCraft II, 2010). This introduces an incredible emphasis on paying attention under tight time constraints, similar to what has typically been found in more traditional action games (Basak, Boot, Voss, & Kramer, 2008; Dale & Green, 2017a, 2017b; Glass, Maddox, & Love, 2013).

As a result of the integration of some action mechanics in the game genre, a number of researchers have investigated the potential impact of real-time strategy (RTS) game play on cognitive performance. For instance, a number of recent cross-sectional studies have indicated that RTS gamers may also show enhancements relative to NVGPs in visual attention and speed of processing (Basak et al., 2008; Dale & Green, 2017a, 2017b; Glass et al., 2013). Furthermore, a true experiment has demonstrated that there may be a causal link between RTS gameplay and enhanced cognitive functioning (Glass et al., 2013). In a parallel to what has been consistently demonstrated with AVGs, Glass, et al. (2013) demonstrated that individuals who were trained on the popular RTS game StarCraft II showed greater improvements in cognitive flexibility as compared with individuals trained on the simulation game The Sims. This finding is in line with the view that the action mechanics cited earlier may be critical to enhancing cognition.

As such, the primary aim of the current study was to further examine the role of action game mechanics by testing the hypothesis that RPG play will be associated with the same types of differences in performance as have been seen with AVG play on both the UFOV task and a MOT task. As noted earlier, the UFOV task measures the ability to extract briefly presented information from a wide and cluttered field of view while dividing attention (Ball, Beard, Roenker, Miller, & Griggs, 1988; Ball & Owsley, 1993). The MOT task measures the ability to track multiple moving target objects in space while ignoring similarly moving nontarget items (Pylyshyn & Storm, 1988). The UFOV and MOT tasks were chosen because AVGPs have consistently been shown to outperform NVGPs on these two measures of attentional skill (Boot et al., 2008; Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003, 2006; Trick et al., 2005; Wu et al., 2012). Given this previous research, a clear AVGP/NVGP difference was expected here. This would then provide an opportunity to evaluate whether RPGPs perform more like AVGPs or more like NVGPs. If RPGPs indeed perform similarly to AVGPs on these tasks, it would provide further evidence that playing games from nonaction genres can benefit cognition.

Figure 1. (A) An example of dialogue options from the RPG game Banner Saga (2014) developed by Stoic Studio and published by versus Evil. The direction of the storyline changes depending on the dialogue choices that the player makes. Dialogue trees and a rich storyline are a staple of most RPG games, whereas combat takes a lesser role (and is traditionally turn-based). (B) An example of dialogue options from a modified version of the action-RPG Fallout 4 (2015) developed by Bethesda Game Studios and published by Bethesda Softworks. Similar to classic RPGs, Fallout 4 uses extensive dialogue and character interactions to drive the storyline forward. (C) An example of combat from the third-person shooter game Max Payne 3 (2012) developed by Rockstar Studios and published by Rockstar Games. The action occurs in real-time, is very fast-paced, and is central to the gameplay. Although there is a storyline, it is secondary to the action and is generally uninfluenced by player actions or choices. (D) An example of combat from the action-RPG Fallout 4 (2015) developed by Bethesda Game Studios and published by Bethesda Softworks. Unlike traditional RPGs, the action in Fallout 4 is presented in real time and is nearly indistinguishable from pure shooter game action. As such, Fallout 4 is best characterized as an action-RPG due to the inclusion of both classic RPG dialogue and storyline development, as well as real-time action sequences. See the online article for the color version of this figure.

Method

Participants

This study was approved by the institutional review board at a large Midwestern university. Participants were recruited from a massive online open course on video games and learning. For this course, one of the coauthors gave a lecture on the impact of action video games on cognition. As a part of this lecture, students were offered the chance to participate in the current study. As such, it is expected that all participants were fully aware of the predicted impact of action gaming/nongaming on cognition. The lecture, however, included no mention of the predicted impact of RPGs (RPGs were identified in the materials as a game genre typically not considered as "action games"). A total of 2,405 students (1,013 men, 604 women, 788 unspecified) ultimately participated in this study. The data of 55 participants who reported being younger than 18 years of age were excluded from further analysis consistent with the approved subject protection protocol (i.e., the protocol was not approved for individuals under 18 years of age). In addition, 132 participants who were either older than 50 years or who reported extreme/impossible ages (19 participants reported ages greater than 100; e.g., 9,843 years old) were excluded. Another 49 participants who skipped the video game questionnaire were also excluded from the analysis. The final data set thus included 2,169 participants (ages ranged between 18 and 50 years; $M = 30.58$, $SD = 8.16$), of which 1,602 completed the UFOV task, and 1,590 completed the MOT task (the order of the two tasks was counterbalanced and not all participants completed both tasks).

Apparatus

The computerized tasks were programmed using the HTML5 canvas element and JavaScript. Participant data were saved in a MySQL database. The participants completed the study on their home computers but were required to conduct a series of calibrations before beginning the tasks to ensure that the visual angle and resolution were appropriate for the tasks (see Yung, Cardoso-Leite, Dale, Bavelier, & Green, 2015 for additional details about the monitor calibration procedure as well as additional detail about the full task programming/implementation). The participants made all responses via manual button presses on their computer keyboard or by using the mouse.

Stimuli and Design

Useful field of view. Each trial began with a blank gray screen that remained for a variable duration (between 16 and 1,440 ms), after which the display appeared on the screen. The display consisted of three parts: distractor shapes, a central fixation target, and a peripheral target (Figure 2). The distractors consisted of squares (subtending 1°) that radiated out along eight lines from a center fixation point at 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315° around a circle. The distractors were presented at locations 3°, 5°, and 7° away from the center fixation (23 distractors in total, with the 24th outer eccentricity location reserved for the peripheral target). Participants were instructed to ignore the distractor squares. The central fixation target was a smiley face (subtending 1°) that had either long (50% of trials) or short (50% of trials) "hair." Finally, the peripheral target was a star subtending 1° of visual angle and was presented simultaneously with the central target and distractors. The peripheral target was always presented at an eccentricity of 7° from fixation at one of eight locations around fixation.

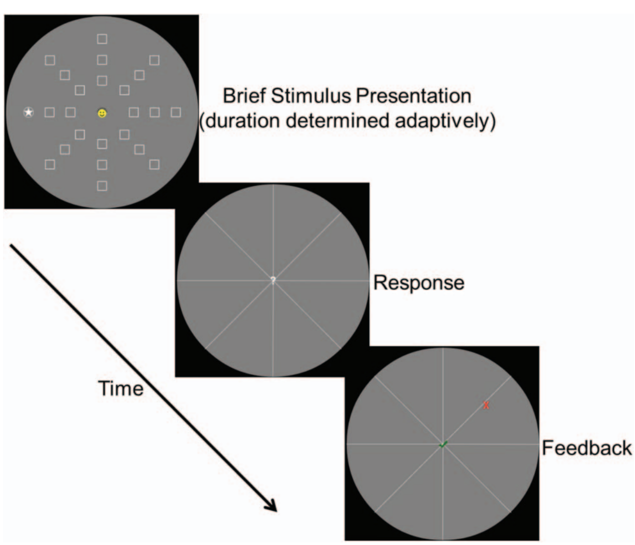

Figure 2. Screenshots from the useful field of view task. Participants briefly viewed a display (top) that contained a central (i.e., the yellow smiley face) and a peripheral target (i.e., a white star inside a circle). After a variable duration, the display was replaced the response display (middle) that contained eight radiating lines. Participants were asked to indicate whether the central target had long or short hair, and on which of the eight spokes the peripheral target had appeared. Finally, participants received feedback (bottom) that indicated whether they had correctly indicated the identity (central) and location (peripheral) of the targets. See the online article for the color version of this figure.

At the beginning of the task, the targets and distractors remained on the screen for a duration of 15 frames (around 240 ms assuming a 60 hz monitor refresh rate—note that the staircase procedure described in the following text utilized frames to control presentation duration, but because the participants' monitor refresh rate was sampled by the software, the data were converted to milliseconds for analysis). After this, the duration varied as the experiment progressed using an adaptive three-down, one-up staircase procedure (i.e., if the participants got three trials in a row correct, the presentation time was reduced; if they got one trial incorrect, the presentation time was increased). A step size of two frames was used until the participant had incurred three reversals (i.e., a transition in the staircase from down-to-up or up-to-down), after which the step size changed to a single frame. The task was terminated after either reversals, or 10 consecutive trials at ceiling (one frame). At the end of each trial, eight spokes appeared in place of the square distractor targets, and participants were instructed to indicate whether the central target had long or short hair by pressing either the "S" (short) or "D" (long) key and to indicate on which of the eight lines the peripheral cue had appeared on by clicking the line with their mouse. After the participant had made their two selections, they received immediate feedback about whether their selections were correct (indicated by a green check mark) or incorrect (indicated by a red X).

Participants were required to complete a set of practice trials containing modified versions of the task before completing the test trials. There were four types of practice trials that were completed in order: identifying the hair length on the central target only, identifying the location of the peripheral target only, identifying both the central and peripheral targets without distractors, and identifying both central and peripheral targets with the distractors present. For each practice step, participants were required to get correct answers on three consecutive trials before moving on to the next step. The duration of the practice trials was fixed at 240 ms per trial.

Due to the shortened format of this task, UFOV performance was calculated by taking the average of the final five trials to obtain a detection threshold (as per Yung et al., 2015). This threshold reflects the minimum presentation duration in milliseconds at which the participants could detect the peripheral target with approximately 79% accuracy.

Multiple object tracking. At the beginning of each trial, participants were presented with an array of 16 circles (0.8° in diameter) that were randomly moving at a rate of 5°/s within a gray circular field (10° in diameter; Figure 3). A subset of circles was presented as blue sad faces (i.e., the cued faces), whereas the remaining circles were presented as yellow happy faces (i.e., the distractor faces). The number of cued faces ranged from 1 to 5, with the single cued face trials presented five times, and the two to five cued face trials presented 10 times each. Trial type was

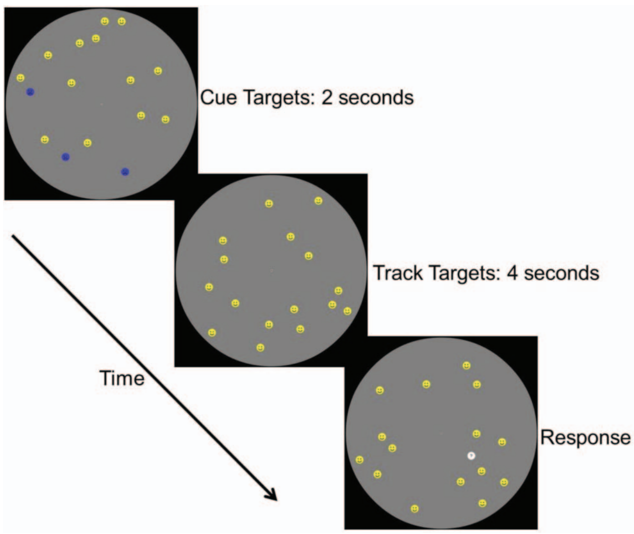

Figure 3. Screenshots from the multiple-object tracking task. Participants initially viewed a display of randomly moving circles and were asked to track the blue circles (top). After 2 s, the blue circles changed to yellow, and participants had to continue tracking the formerly blue circles for 4 s (middle). After 6 s, one of the circles in the display was replaced with a white question mark (bottom), and participants had to indicate whether or not the white circle was one of the circles that they had been tracking. See the online article for the color version of this figure.

randomly intermixed, and there were three blocks of 15 trials for a total of 45 trials.

Participants were instructed to track the blue sad faces throughout the trial. The cued face(s) remained blue for 2 s, after which the face(s) changed into yellow happy faces for 4 s. The participants were instructed to continue tracking the faces that initially were blue, thus the total tracking time per trial was 6 s (2 s with the target indicated and 4 s without). At the end of each trial, a single circle in the display changed color to white with a question mark in the center of the circle (i.e., the probe circle). Participants were instructed to indicate whether this probe circle was one of the originally cued/blue circles by pressing either the “S” key for yes or the “H” key for no. The probe circle was originally a cued/blue circle on 50% of the trials and a distractor circle on 50% of the trials. Participants received feedback on their performance (percent correct) at the end of the first and second blocks.

Before completing the test trials, participants were required to complete a short practice session containing a simplified version of the task. For the practice trials, participants were required to achieve a score of at least three out of four trials correct on 2 one-cued face and 2 two-cued face trials, otherwise they were required to complete two additional practice trials. Practice trials were the same as the test trials with the exception that the circles moved at a slower speed (2°/s), and there were only eight circles present in the display. Mean accuracy for each set size was calculated for each participant and was used as an index of MOT performance.

Procedure

All participants were first required to complete an online survey (created through SurveyGizmo), which was designed to assess their video game play frequency and expertise on six video game genres: action/shooter, RPG, RTS, TBS, music, and other.[1] Questions included the average number of hours per week and weeks per year that they had played various game genres both within and before the past 12 months, the game genre that they most often played, the names of the games that they most often played (e.g., Call of Duty, Bejeweled, World of Warcraft, etc.), and their perceived level of expertise in each game genre (ranging from 0–4 with 0 meaning low/no expertise). At the end of the survey, participants were told to choose a unique, nonidentifying username. Participants were then given a link to a login page. At this login page, participants provided their username to begin the two cognitive tasks. At the end of the first task, they were provided with a link to the next task. Participants were assigned a task order based on a participant number assigned to them after filling out the initial video game survey. Even numbered IDs first completed the MOT task and then moved to the UFOV task, whereas odd numbered IDs first completed the UFOV task and then moved to the MOT task. At the end of the task battery, participants were thanked for their participation and instructed to log out of the system. The study in total took approximately 30 min to complete.

Results

Categorizing Participants Into Gamer Genres

The reported number of average weekly hours spent playing video games both in the current year and in the past were used to classify participants as AVGP, RPGP, or NVGP. In addition, given that previous data have indicated a positive association between playing RTS games and cognitive performance (Basak et al., 2008; Dale & Green, 2017a; Glass et al., 2013), we also considered players of this genre, as well as players of turn-based strategy games (TBSP). Finally, players of “other” games (including music games) were also placed into their own category.

For each game genre in our questionnaire (AVG, RPG, RTS, TBS, music, and “other”), participants could indicate *never* (coded as 0), *0–1* (coded as 1), *3–5* (coded as 3), *5–10* (coded as 5), or *more than 10* (coded as 15) hr per week. Participants were classified as a player of a particular game genre (AVG, RPG, RTS, TBS, music, and other) when they reported at least 5 hr per week of current game play across games from that genre, and no more than 3 hr total on all other genres.[2] Thus, AVGPs are those individuals who play 5 hr or more of action games per week, but not much else. This strategy of only considering “genre-pure” players is important if the goal is to isolate the relationship between playing a given game genre and cognitive performance. Although some authors have attempted to utilize advanced regression procedures to isolate the contribution to cognitive performance of each different game genre played (Unsworth et al., 2015), others have demonstrated that because individuals who play

[1] To access an updated version of this questionnaire, please visit https://osf.io/t72vp/.

[2] Note that the authors also considered the games that individuals reported playing for each genre and factored this into the classification. For example, if a participant reported playing five hr of RPGs, and 0 hr of other genres, but then listed pure RTS games, they would have been classified as an RTS gamer.

multiple genres make substantial and highly nonlinear misestimations of their gaming time (among a host of other theoretical and empirical issues), such procedures are ineffective for assessing the impact of playing certain game genres on cognitive performance (Green et al., 2017). Thus, although there would be interest in examining individuals who play multiple game genres (as these make up the vast majority of gamers), our current methodology for measuring game play (e.g., simple self-report) simply does not support such analyses. Finally, participants were considered as NVGPs if, adding all game genres, they reported no more than 3 hr of total game play currently and in the past year. In all, $n = 76$ participants were classified as AVGPs, $n = 23$ as RPGPs, $n = 19$ as RTSPs, $n = 82$ as TBSPs, $n = 18$ as gamers of other genres (including three music players), and $n = 77$ as NVGPs (see Table 1 for demographic data). As is clear from Table 1, gender strongly covaried with gaming habits; a point that will be addressed both in our analyses and discussed further in the Discussion section.

Performance of AVGPS, RPG Gamers, and NVGPs on the UFOV Task

Although our primary interest was with respect to the RPG group and its relationship with the AVGP and NVGP groups, for completeness we first conducted a one-way analysis of variance (ANOVA) on UFOV thresholds for all of our gamer groups (note that not all participants who completed the video game questionnaire also completed the UFOV task, so the analysis is based on $n = 50$ AVGP, $n = 18$ RPGP, $n = 13$ RTSP, $n = 55$ TBSP, $n = 13$ other, and $n = 28$ NVGP). The ANOVA revealed a significant main effect of gaming experience, $F(5, 171) = 4.71$; $p < .001$; $\eta^2_G = 0.12$ (Levene's test revealed no significant violation of the assumption of homogeneity of variances: $F(5, 171) = 1.56$; $p = .17$), suggesting that performance differed as a function of video game playing expertise (Figure 4A). As expected, and replicating numerous previous reports, Bonferroni-corrected pairwise *t* tests revealed a significant difference in UFOV thresholds between AVGPs and NVGPs ($p < .001$; $d = 1.01$; $BF_{01} = 6.74$), with AVGPs performing better than NVGPs. Critically, a significant difference was also found between RPGPs and NVGPs ($p = .006$; $d = 1.22$; $BF_{01} = 4.02$). Finally, consistent with previous work showing that RTSPs show similar differences in cognitive performance relative to NVGPs as AVGPs, a numerical, albeit nonsignificant, difference was observed between RTSPs and NVGPs ($p = .07$; $d = 1.08$; $BF_{01} = 1.92$). All other contrasts were nonsignificant.

Table 1
Demographics for Gamer Groups

Gamer group	*N*	Age *M* (*SD*)	Sex Male (Female)
AVGP	76	29.6 (8.2)	74 (2)
RPGP	23	27.4 (5.5)	13 (10)
RTSP	19	33.6 (7.9)	15 (4)
TBSP	82	32.6 (9.0)	22 (60)
Other	18	37.8 (9.2)	9 (9)
NVGP	77	34.9 (8.2)	24 (53)

Note. AVGP = action video game player; RPGP = role-playing game player; RTSP = real-time strategy player; TBSP = turn-based strategy player; NVGP = non-video game player.

As noted earlier, our expert AVGP/RPGP groups were primarily male, whereas our NVGP sample was largely female. Furthermore, our AVGP/RPGP samples tended to be slightly younger than our NVGP sample. Thus, to control for the effects of gender and age, we first grouped our participants into six different age groups (1 = 18–24, 2 = 25–30, 3 = 31–35, 4 = 36–40, 5 = 41–45, 6 = 46–50) and then conducted an ANCOVA on UFOV thresholds with gender or age as covariates and gaming experience (only AVGP, RPGP, NVGP) as a between-subjects factor. In both cases, a significant main effect of gaming was still observed: $F(2, 93) = 4.68$; $p = .008$; $\eta^2_G = 0.10$, and $F(2, 93) = 5.49$; $p = .006$; $\eta^2_G = 0.11$, for gender and age as covariates, respectively. Interestingly, though, the reverse 2 (Gender) $\times$ 6 (Age Group) analysis of covariance (ANCOVA) including gaming experience as a covariate did not reveal significant main effects of gender, $F(1, 84) = 0.02$; $p = .88$, or age, $F(5, 84) = 1.23$; $p = .30$, as well as no interaction, $F(5, 84) = 0.62$; $p = .69$.

Finally, to obtain relative importance metrics for age, gender, and video game experience as predictors of UFOV thresholds in AVGPs, RPGPs, and NVGPs, we conducted proportional marginal variance decomposition (Feldman, 2005; Groemping, 2006) using the R package {relaimpo}. The analysis revealed that the three predictors (gaming, gender, and age) accounted for 26.24% of the variance in UFOV thresholds, with the highest relative importance for video game experience at 20.17% of the variance, followed by age with 4.85% and gender with 1.23%.

Performance of AVGPs, RPGs, and NVGPs on the MOT Task

Given that overall MOT performance for Set Size 1 was at ceiling, and performance for Set Size 5 was near chance, we chose to consider performance collapsed across Set Sizes 2, 3, and 4. As with the UFOV, for completeness, we first conducted a one-way ANOVA on all of our gamer groups. The one-way ANOVA (based on $n = 51$ AVGP, $n = 16$ RPGP, $n = 14$ RTSP, $n = 53$ TBSP, $n = 13$ other, and $n = 33$ NVGP; note that there were slightly different numbers of participants who completed the MOT and UFOV tasks) revealed a significant main effect of gaming experience, $F(5, 174) = 2.31$; $p = .046$; $\eta^2_G = 0.06$ (Levene's test revealed no significant violation of homogeneity of variances: $F(5, 174) = 1.28$; $p = .27$; see Figure 4B). Planned Bonferroni-corrected pairwise *t* tests revealed a significant difference in MOT accuracy between the AVGP and NVGP groups ($p = .026$; $d = 0.70$; $BF_{01} = 2.87$). The results for RPGPs were in the expected direction and approached, but failed to reach, significance. The same was true of the RTSPs, but no contrasts approached significance.

Analogous ANCOVAs testing for the effect of action gaming (AVGP vs. NVGP) on MOT accuracy including gender as a covariate did not confirm the main effects of action gaming, $F(1, 82) = 0.11$; $p = .74$; $\eta^2_G = 0.001$, whereas the ANVOCA including age group as a covariate still revealed the main effect of gaming, $F(1, 82) = 5.94$; $p = .017$; $\eta^2_G = 0.07$, indicating that the confound between gaming experience and gender may be more problematic with regard to the MOT task than for the UFOV task.[3] This is

[3] ANCOVAs were only performed with the AVGPS and NVGPs, rather than all of the gaming groups, because only the AVGPs significantly differed from the NVGPs on this task (see Bonferroni-corrected comparisons).

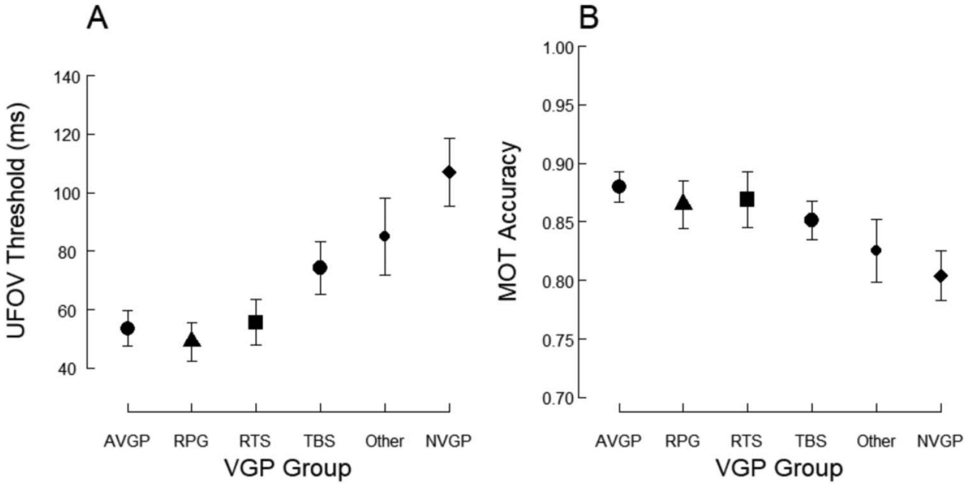

Figure 4. (A) Mean useful field of view thresholds (ms), and (B) accuracy in the multiple-object tracking task (for the different set sizes) in expert action video game players, role-playing game players, real-time strategy game players, turn-based strategy game players, "other" gamers, and nonvideo game players. Error bars indicate standard errors of the mean.

consistent with the fact that the analogous model examining the impact of gender and age group with gaming (AVGP vs. NVGP) as a covariate was also nonsignificant (all Fs < 1.54; all ps $> .19$). In other words, in the MOT task, gaming, gender, and age appear to be accounting for essentially the same variance, making it impossible to uniquely attribute the effects to one or the other. A model containing video game experience, age, and gender as the predictors of MOT accuracy accounted for 11.17% of the total variance, with gender accounting for 5.47%, video game experience for 3.20%, and age for 2.50% of the variance in MOT accuracy at Set Sizes 2 to 4.

Discussion

Numerous studies have demonstrated that regularly playing action video games is associated with enhanced performance on a variety of cognitive tasks, particularly tasks of selective attention such as the UFOV and the MOT (Boot et al., 2008; Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003, 2006; Trick et al., 2005; Wu et al., 2012). AVGs have been of particular interest because these games seem to tax critical attentional components including the ability to attend to multiple items across a wide display, to select targets from within an array of distractors, and to make quick and accurate decisions about those targets (Green & Bavelier, 2003). Other game genres, such as the RPG and RTS genres, have largely been ignored in the literature, with some exceptions (Basak et al., 2008; Dale & Green, 2017a; Glass et al., 2013), because these games traditionally did not contain "action" components. As such, the vast majority of the research on the beneficial effects of playing video games has focused almost exclusively on games from the action genre. However, recent iterations of RPGs increasingly contain action components that are similar to those traditionally seen in action games, suggesting that this game genre should also be associated with enhanced cognitive performance. As such, the primary purpose of the current study was to examine whether RPGPs show better performance than NVGPs on two established attentional tasks (UFOV and MOT) and whether these players would perform similarly to AVGPs. We also examined the differences between gamers of other genres (i.e., RTS, TBS, and "other") to examine how different game genres may be associated with enhanced cognitive abilities or if these enhancements are associated with only specific gaming genres.

Useful Field of View Task

For the UFOV task, we first demonstrated an overall main effect of gaming genre, such that different gaming experiences were significantly associated with different UFOV thresholds. Planned comparisons demonstrated that the AVGPs had significantly lower UFOV thresholds, and therefore outperformed NVGPs, thereby replicating the results of several research groups (Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003; Wu et al., 2012). Interestingly, the RPGPs also showed significantly lower UFOV thresholds than the NVGPs, demonstrating for the first time that playing RPGs is associated with better performance on the UFOV task. Importantly, although our sample is unbalanced with respect to gender and age, the relationship between gaming and performance on the UFOV remained even after age and gender had been accounted for, and gaming experience explained nearly 20% of the variance in UFOV threshold. Overall, these findings indicate that regularly playing games that contain action components is associated with an increased ability to extract briefly presented information from a wide and cluttered visual scene, while dual-tasking.

Multiple-Object Tracking Task

The findings with the MOT task were more variable than for the UFOV task. Although there was an overall effect of group difference on MOT accuracy, planned comparisons revealed that only the AVGPs differed from the other groups in their performance. Again, the finding that the AVGPs outperformed the NVGPs on this task replicates the findings of previous studies (Boot et al., 2008; Dye & Bavelier, 2010; Green & Bavelier, 2003, 2006; Trick et al., 2005). Although numerically the RPG group performed more similar to the AVGPs than the NVGPs, the difference between the RPGPs and NVGPs did not reach the level of statistical significance. Subsequent investigations showed that the analyses were confounded by the relationship between MOT performance and both age and gender. Indeed, age, gender, and video game experience appeared to account for roughly the same variance in MOT performance, thereby making it difficult to determine the unique contribution of each. As such, although the AVGP/NVGP comparison did replicate previous findings, the relationship between RPG gaming and MOT performance could not reliably be determined.

Genre Specific or General?

Our finding that the RPGPs performed similarly to AVGPs on the UFOV task, and were significantly better on the task than the NVGPs, might suggest that this is reflective of a general effect of gaming. However, with the UFOV analysis, we also included a group of individuals (i.e., the "other" category) who primarily played games from genres that do not typically contain action components (e.g., puzzle gamers, music gamers, etc.). These contrasts were not significant, although numerically these other gamers performed more similarly to the NVGPs than to the AVGPs/RPGPs/RTSPs. This suggests that it is not simply the act of playing a video game that is associated with increased cognitive abilities. This has been demonstrated in training studies that have shown that playing action games results in improvements in cognitive performance, whereas playing nonaction games such as Tetris does not benefit cognition (Green & Bavelier, 2003; Bediou et al., 2018).

Our current findings also demonstrated that it is not solely gamers from the "action" genre who show enhanced cognitive abilities, but also gamers from other genres that traditionally did not include games with action components (and now increasingly *do* contain such action components). As such, it is likely that regularly playing any game that contains action components may deliver similar benefits, regardless of the genre to which it belongs. That is, any game regardless of whether it is a minigame, shooter game, strategy game, and so forth may benefit attention so long as it requires the player to rapidly attend to multiple pieces of information at one time, select targets from within an array of distractors over a wide visual field, and make decisions under time constraints.

As more and more games from non-AVG genres begin to include such action components, we anticipate that traditional genre classifications will become less useful. This is true not only of the RPG genre (which increasingly contains action-RPG hybrids), but other genres as well. For instance, although not a focus here, RTSPs showed similar trends as AVGPs and RPGPs (albeit nonsignificant), and our findings were in line with other reported examinations of the relationship between RTS gaming and cognitive performance (Basak et al., 2008; Dale & Green, 2017a, 2017b; Glass et al., 2013). At the moment, the RTS genre includes both individuals who play traditional RTS games (e.g., StarCraft II) and individuals who play games from an emerging RTS subgenre variously called action-RTS or multiplayer online battle arena (MOBA; e.g., League of Legends). At first glance, these games may appear similar (and, in fact, sometimes use the same or similar game layouts). However, MOBAs are far more action-oriented than traditional RTS games, with players usually controlling a single character, battling in teams, and competing in head-to-head matchups against their opponents (Dale & Green, 2017b). As such, games that fall into the MOBA subcategory contain far more action components that regular RTS games.

We thus suggest that researchers begin to move away from genre-based classifications and instead begin examining the actual mechanics of the games that participants play for classification purposes (Dale & Green, 2017b). This is increasingly important, given that much of the research on the beneficial effects of playing games forms the basis for a number of cognitive interventions including treatments for age-related cognitive decline (Toril et al., 2014), children with dyslexia (Franceschini et al., 2013), and individuals suffering from amblyopia (Li, Ngo, Nguyen, & Levi, 2011).

Limitations

There were several limitations to this study that are important to note. The first, and most prominent, was our sample. Unlike the cross-sectional studies completed in the lab where age is fairly controlled, and participants are often limited to a single gender (usually males), our online sample allowed us to recruit a large number of individuals who were more diverse (and thus more generalizable) than the standard sample of pure undergraduate university students. Indeed, our sample contained participants from across a wide range of ages, geographic locations, and education levels. However, this resulted in gamer groups with large age and gender differences, such that our NVGP group included a disproportionate number of older women, whereas our gamer groups contained more young men. As age, and to a lesser extent gender, can influence performance on both the UFOV (Feng et al., 2007; Sekuler, Bennett, & Mamelak, 2000) and the MOT (Trick, Perl, & Sethi, 2005) tasks, this made it difficult to disentangle whether the differences between our gamers and nongamers were due to the age and gender differences between the groups, or gaming expertise. Although we were able to statistically isolate the effect of gaming experience on the UFOV task and were able to demonstrate that gaming experience uniquely accounted for 20% of the variance in UFOV performance, this analysis was less conclusive with the MOT task. As such, although we can conclude that playing AVGs and RPGs is associated with superior performance on the UFOV task, we cannot draw any similar conclusions for the MOT task. Given the significant difference between the AVGPs and the NVGPs, which replicated several previous findings (Boot et al., 2008; Dye & Bavelier, 2010; Green & Bavelier, 2003, 2006; Trick et al., 2005), there is clearly some association between action gaming and MOT performance. However, a more balanced sample would be needed to conclude that playing RPGs influences MOT performance.

A second limitation is that we used only genre-pure gamers. Although this is fairly standard in the field, the vast majority of actual gamers play games from multiple genres, rather than exclusively from a single genre (Dale & Green, 2017a, 2017b). Indeed, this propensity for playing multiple genres has increased over the years and has made it increasingly difficult to recruit genre-pure gamers for research studies (Dale & Green, 2017b). Given that these multigenre gamers make up the majority of the gamer population, studies that examine only genre-pure gamers are not as generalizable to the general gamer community and thus may not provide us with the full picture of how gaming influences cognitive performance. Although at least one study has examined the cognitive benefits of multigenre gameplay (Dale & Green, 2017a), multigenre gamers are notoriously difficult to work with for a variety of reasons. First, they have a tendency to vastly overestimate the number of hours that they play video games (Green et al., 2017). For most of our statistical analyses, we group participants based on these playing-hour estimates. As such it is necessary that we can be reasonably certain that two participants who claim that they play for 4 hr a week do indeed play the same number of hours per week. Unfortunately, we can only control this by either directly measuring the time played or by recruiting solely genre-pure gamers who are less likely than multigenre gamers to overestimate.

Second, multigenre gamers are difficult to categorize because some play just a few different genres, whereas others play several genres over the course of a week. In addition, the number of genres played from week-to-week are rarely consistent, which is clearly not the case with genre-pure gamers (i.e., multigenre gamers might focus on a single genre on a given week, but then might play games from several genres in the next week; Dale & Green, 2017b). Given this inconsistency from week-to-week, it is not only difficult to categorize these gamers but also becomes extremely difficult for them to accurately recall the games, and hours, that they have played (particularly when questionnaires ask them to estimate game play over multiple weeks or their average play over the course of a year).

One final potential limitation is that our gamers, at least in part, were overtly recruited. As part of their lecture on gaming and cognitive performance, participants learned about the association between playing AVGs and cognitive performance and that AVGPs often outperform NVGPs on several cognitive tasks. As such, it is possible that the AVGPs were influenced by this knowledge, which in turn could have contributed to their increased performance on the UFOV and MOT tasks, as compared to the NVGPs. This concern over the potential effects of overt recruitment has been raised by several researchers in the past (Boot, Blakely, & Simons, 2011; Boot, Simons, Stothart, & Stutts, 2013), and although our findings replicate those of several other research groups using covert recruiting, we cannot rule out the possibility that our recruitment method influenced our results. Although it is possible that the AVGPs (and NVGPs) used here were somewhat influenced by knowing the hypothesis a priori, this same argument does not extend to the other gamer groups. The RPGPs would have no reason to believe that they would perform like AVGPs, or outperform NVGPs or gamers from the "other" category, given that the lecture solely focused on the difference between AVGPs and NVGPs. If anything, the RPGPs may have expected to perform more similarly to NVGPs based on the lecture. Thus, it seems less likely that the recruitment method significantly influenced the results for at least these two gamer groups. As such, although it is possible that the recruitment method influenced our results, our findings do not provide support for the overt recruitment hypothesis for the RPG and RTS gamers.

Future Directions

This was the first investigation (to our knowledge) of the relationship between playing RPGs and cognitive performance. We demonstrated that RPGPs performed similarly to AVGPs on a task that required participants to extract briefly presented information from a wide and cluttered visual scene while dual-tasking, and outperformed NVGPs on this same task, suggesting that playing RPGs is associated with enhanced attentional processing. We also demonstrated a similar effect with RTS gamers, suggesting that playing games with action mechanics, regardless of genre, may be associated with increased attentional functioning.

There are a number of future directions that could help clarify how game mechanics influence cognitive processing. First, a training study using action-RPG games would be of interest. Action-RPGs contain both heavy action segments that are nearly indistinguishable from traditional action games and pure RPG segments that are more reminiscent of classic RPG games. It would be potentially valuable to train individuals on these games and examine whether the amount of time spent playing the more "action-like" aspects is predictive of cognitive performance (these elements are reasonably distinct and thus it would be possible to separate them in a post hoc analysis). It would also be interesting to see whether these gamers perform similarly to just action gamers. This might also provide an opportunity to tease apart the specific game mechanics that are driving changes in cognitive performance.

Second, it may be of interest to begin examining gamers from other genres that are not typically classified as "action". For example, most minigame players (i.e., cell phone, tablet, or Facebook games) are lumped into an "other" category or into a nongamer category. However, minigames themselves arguably span multiple genres, and many contain action components. Indeed, one major issue with the "mini-game" genre is that, unlike other genres, it is based primarily on the gaming platform (mobile devices) rather than the game mechanics. As such, it would be valuable to examine the cognitive performance of a variety of gamers from non-AVG genres to further test the hypothesis that genre is irrelevant and to better understand the game mechanics that lead to cognitive benefits (see Oei & Patterson, 2013 for an examination of the benefits of mini games, and Cardoso-Leite, Joessel, & Bavelier, in press). Such a perspective would have the knock-on effect of allowing for more refined meta-analyses—as most current meta-analyses have either restricted analyses to just the narrow definition of action-games utilized in the literature (Bediou et al., 2018) or else have used a much broader definition (starting with all games; Powers et al., 2013; Sala et al., 2018).

Overall, our findings suggest that researchers begin moving beyond traditional genre classification systems and begin exploring the mechanics of games rather than the genre. Although our findings were by no means conclusive given the cross-sectional nature of the study, we nonetheless provided some of the first evidence that RPG players may show enhanced cognitive abilities relative to nongamers.

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