Experience and Training of a First Person Shooter (FPS) Game Can Enhance Useful Field of View, Working Memory, and Reaction Time

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Abstract: To examine the effects of experience and training of a first person shooter (FPS) game on cognitive abilities, we conducted three experiments in which participants performed useful field of view (UFOV), visual working memory (VWM), and reaction time (RT) tasks. In Experiment 1, we compared performance on the three cognitive tasks between FPS players and non-FPS players. In Experiments 2 and 3, changes in task performance after 10-hr training or no training on the FPS game were examined. Experiment 1 showed that FPS players performed better than did non-FPS players on all cognitive tasks. Experiment 2 showed higher performance on all cognitive tasks after the training compared with those before it. Experiment 3 showed no enhancement of performance on all tasks. These results indicate that FPS game experience and/or training can enhance cognitive abilities at least for UFOV, VWM, and RT.

Keywords: Action video game, cognitive abilities, training effect

1. INTRODUCTION

The recent development of video game devices and portable electronic devices (including mobile phones and tablet devices) enables us to play video games at any time and place. As a result, video game playing has become one of the most popular entertainment activities in today’s society. Although early studies have reported potential negative effects associating with the abusive use of video games [1-3], recent studies suggest that video game playing may enhance perceptual and cognitive processes, such as attention [4-9], memory [10-12], and speed of information processing [13, 14] (see for reviews [15, 16]). For example, Green and Bavelier [4] reported enhancement of various aspects of visual attention by action-video game playing. In their experiments, attentional capacity and its spatial distribution and temporal resolution were compared between habitual action video game players (AVGPs) and non-video game players (NVGPs). They found that the attentional capacity was larger, its distribution wider, and its temporal resolution higher in the AVGPs than in the NVGPs. Green and Bavelier also examined how training on an action-video game affected attention in NVGPs. They found that the training (i.e., 1 hr per day for 10 days) significantly enhanced all aspects of the attention abilities mentioned above (see also [5, 6]).

Colzato et al. [10] extended the findings of Green and Bavelier [4] and subsequent studies (e.g., [5-9]) by examining the effects of action video game experience on working memory. In their study, AVGPs and NVGPs performed an n-back task in which they were required to indicate whether each stimulus (i.e., letter) presented sequentially matched the one that was presented n items ago. Colzato et al. found that the AVGPs determined the target more quickly and accurately than the NVGPs did, suggesting that the capacity of working memory is larger in AVGPs than in NVGPs. Blacker and Curby [11] reported a higher capacity of working memory in the AVGPs than in the NVGPs by using a visual working memory task [17] in which multiple colored squares are briefly presented and participants have to memorize them and report the color for one of the squares.

Although many studies have reported the enhancement of cognitive abilities by experience and/or training of action video games, other investigators have reported inconsistent findings [18-20] (see also [15]). For example, Boot et al. [18] measured a wide range of cognitive abilities, including attention, memory, and executive control, for AVGPs and NVGPs. They also measured those cognitive abilities for NVGPs with training on an action-video game, a puzzle game, or a real-time strategy game (for 20 hrs). Although they found higher performance in cognitive tasks, such as visual working memory and multiple object tracking tasks in the AVGPs compared to the NVGPs, attentional capacity and its spatial distribution and temporal resolution did not differ between the two groups (see also [19]). There was no difference in n-back task performance between the two groups.
The reason for the discrepant findings is not clear. Strobach et al. [21] speculated that the findings in Boot et al. [18] may have been confounded by fatigue and/or other carryover effects, because in Boot et al.’s study, participants performed 12 tasks (see also [15]).

The present study was designed to obtain a better understanding of the effects of action video game on cognitive abilities, such as attention and working memory. In the present study, we used a first person shooter (FPS) game, a genre of action video game, which has been used in many previous studies. A FPS is a gun shooting game undertaken through a first-person perspective. Therefore, through the limited visual field of the character being manipulated, players must quickly and accurately search visual information and select appropriate behaviors in response to visual objects (e.g., enemies and items) and events (e.g., attacks from enemies).

We focused on three cognitive tasks to measure the spatial range of attention (i.e., useful field of view; UFOV), visual working memory (VWM), and reaction time (RT). As mentioned above, because of the limited visual field and nature of the task required in FPS games, players must search visual objects quickly and accurately, not only in the central visual field, but also in the peripheral field. In addition, players must frequently update information in their working memory and, according to that information, must select appropriate behaviors quickly and accurately. In the present study, we also measured the game scores after the cognitive tasks.

In the present study, we conducted three experiments. In Experiment 1, we examined the effects of the FPS game experience by comparing the performance in the cognitive tasks between habitual FPS game players and non-FPS game players. In Experiment 2, we examined the effects of FPS game training on the task performance. In Experiment 3, we also conducted a control condition in which non-FPS game players were asked to perform the cognitive tasks without game training.

2. EXPERIMENT 1

2.1 Method

2.1.1 Participants

Twenty-nine individuals participated, 14 FPS players (all males with a mean age of 21.5 in the range of 18-24) and 15 non-FPS players (twelve males and three females with a mean age of 22.0 in the range of 18-25). FPS players reported playing FPS games such as Call of Duty, Halo, and Battle Field series, more than 4 hrs/week (mean of 6.4 hrs/week in the range of 4-16 hrs/week), and non-FPS players reported no experience with FPS games or had not played for over a year. Note that all of the FPS players also reported playing various genres of action video games, including sports, car racing, fighting, and shooting games (third-person perspective). All the participants gave informed consent to participate in the experiment. They had normal or corrected-to-normal vision.

2.1.2 Apparatus

In the cognitive tasks, a personal computer (Apple Mac Pro Early 2009) was used to control the experiment and generate stimuli used. All stimuli were presented on a 22-inch color CRT monitor (refresh rate at 100 Hz) at a viewing distance of 57 cm. The experimental program was written with MATLAB with Psychophysics Toolbox extensions [22,23]. In the game task, the video game was played on the Playstation 3 (Sony Computer Entertainment Inc., Japan) with the accompanying controller, connected to a 20-inch color LCD monitor (refresh rate at 60 Hz). We used the commercially available FPS game “Call of Duty: Modern Warfare 3” (ActiVision Inc., U.S.A.).

2.1.3 Stimuli

Figure 1 is an illustration of the tasks used in the present study. A UFOV task used in the present study was quite similar to that used in previous UFOV studies [24-26] (see Figure 1A). In the display subtending 40° (W) × 30° (H), a fixation stimulus, circular frames, a central target, a peripheral target, and masks were presented in white on a grey background (luminance 29.6 cd/m²). The fixation stimulus (figure 8) subtended 0.8° × 1.0° and was presented in the center of the display. Each frame (luminance 54.5 cd/m²) subtended 1.2° in diameter. The frames were aligned at 4°, 12°, and 20° in the periphery from the center of the display along four imaginary radial spokes. The central target was a single letter (luminance 54.5 cd/m²) subtending 0.8° × 1.0°. The central target was one of four characters (E, F, H, or L) presented at the center of the display. The peripheral target was a single spot subtending 1.0° in diameter. The peripheral target (luminance 33.2 cd/m²) was presented inside one of the frames. The masks were filled circles (luminance 54.5 cd/m²) with a 4 × 4 diagonal cross line pattern, subtending 1.2° in diameter. They were presented at all frame locations as well as the central target location.

A modified version of the VWM task described by Luck and Vogel [17] (see also [11,12]) was used (Figure 1B). In the display, a fixation cross, a sample array, and a test stimulus were presented on a grey region (luminance 42.2 cd/m²) subtending 9.88° × 7.38°, outside of this was black (luminance 0.56 cd/m²). The fixation cross was
black and subtended 2° × 2°. The fixation cross appeared in the center of the display through a trial. The sample array contained 2, 4, 6, or 8 colored squares (1.6° × 1.6°). The color of each square was randomly chosen from a set of nine clearly discriminable colors, i.e., red (luminance 15.2 cd/m²), brown (luminance 4.52 cd/m²), blue (luminance 7.24 cd/m²), cyan (luminance 55.2 cd/m²), violet (luminance 6.46 cd/m²), green (luminance 48.4 cd/m²), yellow (luminance 63.1 cd/m²), black (luminance 0.56 cd/m²), and white (luminance 69.9 cd/m²), and each color appeared only once in an array. The positions of the squares were randomized for each trial, and the samples in a given array were separated by at least 2.0° (center to center). The test stimulus was presented at one of the square positions presented on the sample array. The test stimulus was divided into two colored rectangles; one rectangle was the same color as the sample square that had been presented at that position, and the other was a color that was different.

In the RT task (Figure 1C), a white fixation cross and a target (luminance 69.6 cd/m²) were presented in the center of the gray background (luminance 42.2 cd/m²). The fixation cross subtended 2° × 2°. The target was filled circle subtending 2° in diameter.

2.1.4 Procedure

In the experiment, there were two sessions; one was a cognitive task session, and the other was a game task session. We conducted the cognitive task session first, followed by the game task session. In the cognitive task session, the three tasks were conducted in a dark booth. Each participant sat on a chair with his or her head fixed by a chin rest while viewing the display binocularly. The order of the three cognitive tasks was randomized across the participants. Before the main experiment, the participants practiced the tasks until they were familiar with them, after which the main session began. The duration of the three cognitive tasks was less than 1 hour. In all tasks, participants could take rest periods whenever they felt fatigued.

In the UFOV task, at the beginning of each trial, the word “Ready” was presented in the upper middle of the display until the participant pressed the space key to begin a trial. After pressing the key, the central fixation stimulus and the circular frames were presented for 1 s. The display was then replaced by the central and peripheral target display for 100 ms and the masks were then presented for 1 s. Following the offset of the masks, four possible central targets and frames were presented until the participants responded by pressing one of four labeled keys on a
keyboard. The frames for the four possible locations were then presented with each radial spoke labeled “1,” “2,” “3,” or “4” until the participants responded by pressing one of four labeled keys on the keyboard. The participant’s task was to identify the central target (central task) while localizing the peripheral target (peripheral task). After each trial, auditory feedback for the central task alone was provided. There were two blocks of 72 trials. The central target and frame at which the peripheral target was presented were chosen randomly across trials with an equal number of occurrences. The proportion correct responses (PCRs) for each central and peripheral task were calculated.

In the VWM task, at the beginning of each trial, the word “Ready” was presented in the upper middle of the display until participants pressed the space key to begin a trial. After the key press, the central fixation cross was presented for 1 s. The display was then replaced by the sample array for 100 ms and a blank display was then presented. Two seconds after the onset of blank display, the test stimulus was presented. The test stimulus disappeared if one of the two labeled keys on the keyboard was pressed or 2 seconds elapsed. The participant’s task was to memory the colors and positions of the squares and to report which color from the test stimulus was the same as the square that had been presented in that position. There were 200 trials. The item set size (2, 4, 6, or 8) was chosen randomly across trials with an equal number of occurrences. Again, the proportion correct response (PCR) was calculated.

In the RT task, at the beginning of each trial, the word “Ready” was presented in the upper middle of the display until participants pressed the space key to begin a trial. After the key press, the central fixation cross was presented for 1 s and the cross was replaced by the target to be responded until a labeled key was pressed or 1 s elapsed. The participant’s task was to respond to the onset of the target, as soon as possible. There were 100 trials. In 20% of the total trial, no target was presented (i.e., catch trial) for participants to prevent an anticipatory response. The mean RT and false alarm rate were calculated.

In the game task session, the task was conducted under a standard illumination. Participants sat on a chair and no apparatus was used to fix their head position relative to the video game monitor. The participant’s task was to play the FPS game. Because most FPS players reported that they could play the game for 30 min or longer per play, the participants were asked not to buy weapons or armors during the game and each trial was terminated when the “GAME OVER” message was displayed or 10 min after the start of the game. There were three trials. The mean game score was calculated.

2.2 Results

Figure 2 shows the results of Experiment 1. As seen in the figure, for all cognitive tasks and game task, the performances were higher for the FPS players than for the non-FPS players. Figure 2A shows the mean PCRs in the peripheral tasks. As seen in the figure, PCRs were clearly higher in the FPS players than in the non-FPS players in the peripheral task. In both groups, PCRs decreased with increasing eccentricity. The peripheral task performance data were entered into a 2 (group) × 3 (eccentricity)
ANCOVA, which showed significant main effects of both group, \( F(1, 27) = 6.28, p < .05 \), and eccentricity, \( F(2, 54) = 70.12, p < .01 \). An interaction between group and eccentricity was just above the significance, \( F(2, 54) = 2.94, p = .062 \). A post-hoc comparison by Tukey’s HSD method showed significantly lower PCRs at the 20-deg eccentricity compared to the other eccentricities (both \( ps < .05 \)). Concerning the central task performance, a \( t \) test revealed no significant difference between the FPS players (mean = 97.12) and the non-FPS players (mean = 95.14).

Figure 2B shows the mean PCRs in the VWM task. As seen in the figure, PCRs were higher in the FPS players than in the non-FPS players. A 2 (group) \( \times \) 4 (set size) ANOVA showed significant main effects of both group, \( F(1, 27) = 5.15, p < .05 \), and set size, \( F(3, 81) = 149.18, p < .01 \). There was no interaction between them. A post-hoc comparison showed significant differences in PCRs between any pair of set size conditions (all \( ps < .05 \)).

Figure 2C shows the mean RTs. The RT was shorter in the FPS players than in the non-FPS players. The \( t \) test result showed that the RT difference between the two groups was just above the significance, \( t(27) = 2.05, p = .0504 \). Concerning the error rate (i.e., false alarm rate), there was no significant difference between the FPS players (mean = 0.03) and non-FPS players (mean = 0.04).

Figure 2D shows the mean game scores in the FPS and non-FPS players. A \( t \) test revealed significantly higher scores in the FPS players compared to the non-FPS players, \( t(27) = 11.37, p < .01 \). We also conducted additional analyses of the correlations between the game score and each of the three cognitive task performances. Note that the PCRs to the peripheral target of the UFOV task and those in the VWM task were averaged across the conditions of eccentricity and set size, respectively; the averaged data were used for the correlational analyses. Results showed significantly positive correlations with performance in UFOV, \( r(27) = 0.53, p < .05 \), and VWM tasks, \( r(27) = 0.38, p < .05 \), while the correlation was not significant with performance in the RT task.

2.3 Discussion

In this experiment, we measured performance in the UFOV, VWM, and RT tasks for FPS players and non-FPS players; we found that FPS players had higher performance in all tasks compared to the non-FPS players. This finding is consistent with the findings of previous studies that examined attentional abilities [4-6], working memory [10-12], and speed of information processing [13,14]. As mentioned in the Introduction, there are discrepant findings from studies examining the effects of action video game on attention and memory [18-20]. The present study provides positive evidence for the literature.

As argued by Strobach et al. [21], the studies reporting negative findings [18-20] might have been confounded by fatigue and other carryover effects. The present study minimized these possibilities (short task duration and only a few tasks were required). Therefore, the present study would have revealed the clear differences between the groups.

It should be noted that in the present study’s UFOV task, the PCR to the central target in the FPS players was not different from those in the non-FPS players. This is inconsistent with the findings of Green and Bavelier’s [5] findings which showed that FPS players had significantly higher performance for the central target of the UFOV task than did the non-FPS players. One possible reason for this discrepancy is the methodological differences between the present experiment and Green and Bavelier’s experiment. In their experiment, to equalize the non-purposeful effect (i.e., eccentricity) the stimulus presentation duration was varied depending on the eccentricities. Consequently, the higher central task performance may have reflected not only the accuracy of information processing, but also its speed, resulting in the differences between the two groups. The present study used a UFOV task with no manipulation of the presentation duration (e.g., [26]). Therefore, the central task performance may have been independent for the speed of information processing.

Note that in the present study’s RT task, the target was presented in the center of the display and RT to it were faster in the FPS players than in the non-FPS players. This result may partially support the findings of the higher central task performance in Green and Bavelier.

The results of the correlation analyses showed that the performance in the UFOV and VWM task were significantly related to the game score. This result strengthens the view that the experience of the FPS game can enhance cognitive abilities such as attention [4-6] and working memory [10-12].

3. EXPERIMENT 2

3.1 Method

The apparatus and stimuli used in Experiment 2 were identical to those used in Experiment 1. Participants were 8 individuals who had participated in Experiment 1 as non-FPS players. In the experiment, they received 10-h training (e.g., [4,8]) on the FPS game used in Experiment 1 (i.e., Call of Duty). During the training period, participants were asked to play the game in our laboratory for 1-3 hr
per day. The 10-hr training was completed over 4 or 5 days in 2 weeks (after participating in Experiment 1). After the training period, they performed the cognitive tasks and game task mentioned in Experiment 1.

3.2 Results and Discussion

Figure 3 shows the performance of the cognitive tasks and game task in Experiment 2, as well as Experiment 1 (pre-training). As seen in the figure, performance in all the cognitive tasks and game task became higher after the 10-hr training. In the UFOV task (Figure 3A), the peripheral task performance data were entered into a 2 (training period) × 3 (eccentricity) two-way ANOVA, which showed significant main effects of both training period, $F(1, 7)=6.36, p<.05$, and eccentricity, $F(2,14) = 28.86, p<.01$. An interaction between training period and eccentricity was significant, $F(2,14)=8.42, p<.01$. A post-hoc comparison showed significantly lower PCRs at the 20-deg eccentricity compared to the other eccentricities (both $ps<.05$). Subsequent analyses of the interaction showed a significant simple main effect of training period at the 12-deg, $F(1,21)=7.37, p<.05$, and 20-deg eccentricities, $F(1,21)=11.51, p<.01$. On the central task performance, there was no significant difference in the central task performance between the two periods (the mean PCR was 93.48 and 93.58 in the pre and post periods, respectively).

In the VWM task (Figure 3B), a 2 (training period) × 4 (set size) two-way ANOVA showed significant main effects of both training period, $F(1,7)=19.88, p<.01$, and set size, $F(3,21)=89.74, p<.01$. There was no interaction. A post-hoc comparison showed significant differences in PCRs between any pair of set size conditions (all $ps<.05$).

In the RT task (Figure 3C), the $t$ test results showed a significant difference between the two periods, $t(7)=2.85, p<.05$. However, the difference in the error rate was not significant (the mean error rate was 0.03 and 0.04 in the pre and post periods respectively). In the game score (Figure 3D), the result of the $t$ test showed a significantly higher game score in the post training, $t(7)=7.31, p<.01$.

The results of Experiment 2 are consistent with those of Experiment 1 and previous studies examining effects of game training on attention [4-6], working memory [10-12], and speed of information processing [13, 14]. This suggests that the FPS game training, as well as the FPS game experience, can enhance the spatial distribution of attention.

As mentioned in Experiment 1, this discrepancy can be explained by the methodological differences between the present experiments and their experiment.

4. EXPERIMENT 3

4.1 Method

The apparatus and stimuli used in Experiment 3 were identical to those used in Experiment 1. Participants were 7 individuals who had participated in Experiment 1 as non-FPS players, but who had not participated in...
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Experiment 2. In the experiment, they received no training on the FPS game. Two weeks after Experiment 1, they came to our laboratory and performed the cognitive tasks and game task.

4.2 Results and Discussion

Figure 4 shows the performance of the cognitive tasks and game task in Experiment 3, as well as Experiment 1 (pre-test). As seen in the figure, no enhancement of performance in any of the cognitive tasks or game task was found. In the UFOV task (Figure 4A), a two-way (task repetition × eccentricity) ANOVA showed only a significant main effect of eccentricity, $F(2, 12)=15.41$, $p<.01$, but the main effect of repetition and interaction were not significant. A post-hoc comparison showed significantly lower PCRs at the 20-deg eccentricity than at the other eccentricities (both $p<.05$). Note that the difference in the central task performance between the 2 periods was not significant (the mean PCR was 97.22 and 96.53 in the pre and post periods, respectively).

In the VWM task (Figure 4B), a two-way (task repetition × set size) ANOVA showed only a significant main effect of set size, $F(3, 18)=82.47$, $p<.01$, but the main effect of task repetition and interaction were not significant. A post-hoc comparison showed significant differences in PCRs between any pair of set sizes (all $p<.05$) except between the 6 and 8 set sizes.

In the RT task (Figure 4C), the $t$ test showed no significant difference in the RT between the two periods. There was no significant difference between the two in the error rate (the mean error rate was 0.04 and 0.00 in the pre and post periods, respectively). In the game score (Figure 4D), the result of the $t$ test showed no significant difference between the two periods.

The results of Experiment 3 showed no enhancement in the performance of the cognitive tasks, suggesting that the repetition of the cognitive tasks cannot account for the enhancement of the cognitive tasks reported in Experiment 2. Because the patterns of the results (i.e., the dependency of the PCRs on the eccentricity in the UFOV and on the set size in the VWM task) was quite similar between Experiments 2 and 3, it is unlikely that the participants in this experiment adopted different strategies from those used by the participants in Experiment 2.

5. GENERAL DISCUSSION

The present study examined the effects of FPS game experience (Experiment 1) and training (Experiments 2 and 3) on cognitive abilities using UFOV, VWM, and RT tasks. The results of Experiment 1 clearly showed higher performance on the cognitive tasks in the FPS game players than in the non-FPS game players. This suggests that the FPS game experience enhances the spatial distribution of attention, capacity of working memory, and information processing speed. Experiment 2 showed that the 10-hr training of the game in the non-FPS game players enhanced performance of the cognitive tasks, while Experiment 3 showed that the repetition of the cognitive tasks did not enhance performance of the tasks. These
results suggest that the FPS game training can enhance cognitive abilities. Taken together, the present results of the three experiments clearly indicate that the experience and the training (at least for 10 hrs) of FPS game can enhance attention [4-9], working memory [10-12], and information processing [13,14]. Considering that working memory is well known to be related to attention [27], the FPS game would be useful, at least some degrees, for enhancing attention-related cognitive abilities.

As discussed in the Introduction, several studies have reported mixed results for the effects of video game experience or training on cognitive abilities [18-20]. This is inconsistent with the present results of Experiments 1 and 2. This discrepancy could be due to carryover effects, namely, experience with and repetitions of cognitive tasks. As we mentioned earlier, Boot et al. [18] used 12 cognitive tasks. In Ravenzwaaij et al. [20], participants played video games on five separate days. Before each game session and following the last session, they performed a visual discrimination task. It is, therefore, possible that experience with various cognitive tasks and repetitions of a task enhanced cognitive task performance and concealed the effects of video games on cognitive abilities. Indeed, these studies showed that task performance was enhanced in the no-training group, unlike in the case of Experiment 3 of the present study. In order to reveal the effects of video games on cognitive abilities, it would be necessary to limit the number of tasks and the repetitions of the tasks.

One may argue that the difference in the cognitive tasks would reflect the changes in cognitive strategies, not the enhancement of cognitive abilities. For example, Nelson and Strachan [28] reported that 1 hr playing for the video game affected speed-accuracy tradeoff of players to both localization and shape-matching tasks, depending on game genres used. In their study, participants performed the two cognitive tasks before and after the 1 hr video game playing. Two types of video games were used: a FPS and a puzzle game. Their results showed that participants’ responses became faster but less accurate in both tasks after the FPS game playing than before the playing. After the puzzle game playing, participants’ responses became slower but more accurate than before the playing. According to the explanation by the influence of game play on a tradeoff strategy, it would be expected that the FPS players and the non-FPS players after the FPS game training traded off their response accuracy for faster responses. However, the results of RT task in Experiments 1 and 2 showed faster RT in the FPS players than in the non-FPS players (Experiment 1) and after the training period than before the period (Experiment 2) with no change in error rate (false alarm rate). In addition, the results of UFOV and VWM tasks in Experiments 1 and 2 also showed higher accuracy of responses (i.e. PCRs) in those tasks in the FPS players than in the non-FPS players (Experiment 1) and after the training than before the training (Experiment 2). Taken together, it is unlikely that the present findings can be accounted by the speed-accuracy tradeoff. Note that in the UFOV task, we found no change in the PCR to the central target between the FPS and non-FPS players (Experiment 1) and between the training periods (Experiment 2). Therefore, it is unlikely that the peripheral task performance was traded off with central task performance.

The present study did not examine the effects of other types of video games such as puzzle games. Therefore, it is not clear whether the effects of video games observed here are specific to FPS games. We speculate that other types of video games would be able to enhance the cognitive abilities measured in the present study if the games require players to quickly and accurately perceive relevant information, as in a FPS game. Seya and Watanabe [29] measured UFOV in game playing situations. In their study, the peripheral visual field was restricted to an area around the gaze by a window mask, while participants played one of three video games, namely, car racing, falling puzzle, and word puzzle games. They found that in the word puzzle game, game score did not change with the mask; however, in the other games, game score decreased as the mask size increased. This suggests that UFOV is essential for playing video games wherein the opponents impose severe spatial and temporal constrains on players (see also [30]). Boot et al. [18] and Ravenzwaaij et al. [20] reported that players’ cognitive abilities were enhanced irrespective of the type of game used for training. However, their findings may have been confounded by other factors as we discussed above.

It should be noted that our findings do not imply that FPS game playing results in the enhancement of general cognitive abilities required for various situations such as driving and sports. Sports vision research has provided evidence supporting this view. Mori et al. [31] measured simple and choice RTs in karate athletes and novices. They reported faster RTs in the athletes than in the novices when the tasks consisted of videotaped scenes of the opponent’s attack; however, when simple stimuli were used, the difference was slight. This suggests that training in a specific sport enhances the cognitive abilities required for that sport or for tasks closely related to it (see also [32]). A similar argument may be applicable to
the effects of FPS game experience and training. Further investigation is needed to explore this point.

In conclusion, the present study provides positive evidence regarding the effects of FPS game experience and training on UFOV, VWM, and RT. The results suggest that the number of tasks employed and the repetitions of the tasks should be limited in order to eliminate potential carryover effects. However, we believe that the effects of video game should be examined by using multiple tasks, in order to examine whether the enhancement of task performance reflects cognitive strategies, such as a speed-accuracy tradeoff.

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