Video Gaming and Visual Attention

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Abstract

This literature review looked at studies that sought to explore the relationship between visual attention and video game playing. Video game players have been shown to have a higher attentional capacity than non-video game players. With some mixed results, this effect does appear to be trainable, specifically when similar skills can be found in the game or genre itself. Video game players also appear to have greater brain plasticity of regions involved with visual processing, but long term use may be linked with problems in attention and impulsivity.

Keywords: video games, visual attention

Video Gaming and Visual Attention

Video game playing has become a more common past-time in recent years, bringing with it speculation about improvement from practicing game related skills along with fears of detrimental health effects to developing adolescents. The skills required to effectively play video games are often related to greater visual attention and processing abilities in addition to minor motor actions like reaction time. The rise of eSports especially and it's parallels to physical sports opens up questions about the effects of training compared to natural advantages in visual attention.

Action video games show a large prevalence across the research of visual attention, likely due to the size and age range of their player bases. These games tend to have a greater requirement for attentional capacity and processing and are therefore more likely to show an effect. With this does come the exclusion of female game players from their comparatively low involvement in playing action video game genres. For this reason, quite a few studies rely exclusively on male participants despite demographics showing a close to even split in the overall community of game players.

Research in this area often focuses on the differences in various aspects of visual attentional in VGPs compared to NVGPs with a focus on improvements shown from action video games. Further investigation into the relationship of this correlation is done through training NVGPs for a few weeks and looking at any improvements made in game-specific skills as well as transferable skills to visual attention tasks. Some research also looks at the long-term effects of video game playing, which can be especially important given the play habits of developing adolescents.

Visual Attention Improvements in Video Game Players

The simplest way to observe the effects of video gaming on visual attention is to compare VPSs and NVGPs performance on various tasks. There are a number of attention-based tasks in which Action video game players (AVGPs) in particular seem to outperform NVGPs. Action video games have been widely studied due to their popularity and mechanical consistency across game titles. These titles often involve quick movements, multiple object tracking, and monitoring peripheral vision for incoming threats. Appelbaum et al. (2013) identified AVGP's through self-ratings of expertise on "action/platforming" or "first-person shooter" (FPS) games.

Task switching in particular often shows improvement in AVGPs as seen in Doborowolski et al. (2015) where VGPs who played either RTS or FPS players had less of a task-switching cost than NVGPs in terms of their reaction time. There was, however, still some difference based on the genre of the game. While both groups performed better than NVGPs, RTS players had faster reaction times and better perceptual sensitivity than FPS players. Although FPS games may appear to have a higher requirement for these skills, this is likely due to the greater constant attentional demands that come from RTS games. This also helps illustrate that improvements to visual attention may be game or genre-specific and depend on actions required by the game.

Appelbaum et al. (2013) employed a visual sensory memory (VSM) test to assess abilities in retaining and utilizing information stored in iconic memory, a fast decaying visual storage. They found that while AVGPs show a greater capacity for this type of memory compared to NVGPs, there is no difference in the decay rate of their iconic memory. This showed that AVGPs rely on the greater availability of information rather than the persistence of that information to make informed decisions. Dale et al. (2020) showed that similar

improvements can be also be observed in role-playing game players (RPGP) in the useful field of view (UFOV) and multiple object tracking (MOT tasks. UFOV and MOT seem to be the tasks that most resemble scenarios and skills that come up in action video gameplay. While the slower pace of role-playing games may show a contradiction the genre-specific skill development, this may be due to recent shifts in the genre away from narrative conflict to more action-oriented conflict. Even without this perceived shift, these studies point towards a greater capacity in the visual attention of VGPs, but not necessarily improvement to its accuracy. This can be seen in the findings of Boot et al (2008) where during spatial processing tasks VGPs show greater speed but are no more accurate than NVGPs.

Impact of Training Non-Video Game Players

A large section of the research focuses on the effects of training NVGP on various genres of video games to see if any improvements can be made. This often involves looking at game-specific tasks as well as transferable skills to previously mention measures of visual attention. In a longitudinal study, Boot et al. (2008) showed that with 15 training sessions over a five-week period NVGP's trained using various action video games showed improvements in game-specific tasks. This included target accuracy and the number of kills in a first-person shooter game. However, when looking at their transferable skills to several visual and attentional tasks such as attentional blink and UFOV, their improvement was not significantly different than those who received no video game training experience at all. They speculate that training was ineffective due to the natural abilities of NVGPs. It may be the case that only VGPs who show greater attentional, perceptual, and cognitive capacity are likely to spend time playing games that challenge this skillset. This is illustrated most clearly on the multiple objects tracking task where

expert VGPs far outperformed NVGPs, even when NVGPs trained with games that specifically practice this skill.

There are, however, a number of studies that contradict these findings and show greater attentional capacity after training. Belchior et al. (2013) were able to improve the selective visual attention of older adults aged 65 – 91 with only a few weeks of training. When trained on the same Medal of Honor game as in Boot et al. (2008), older adults showed transferable improvement in the UFOV test of selective attention. This finding was consistent with training improvements shown in adolescents in Green and Bavelier (2003). Both studies also used Tetris as a placebo control since the game does not challenge visual selective attention. Older adults showed almost identical improvement in the useful field view task after playing Tetris, while adolescents only showed minimal improvement. This is likely due to the learning challenges both games provide to older adults who, unlike adolescents, take some time to familiarize themselves with typical game controls.

Other visual attention tasks have been shown to improve with video game training. Oei and Patterson (2013) had NVGPs use mobile games 5 days a week for 4 weeks. Just like in the previous studies, an improvement was seen in the UFOV task. They were also able to show increased attentional blink capacity in participants trained with Action video games, but no difference in MOT. Non-action video games were also shown to improve both visual search and spatial working memory. Kim et al. (2015) were also able to show improvement in NVGPs accuracy and reaction time on a texture discrimination task given 12 training sessions over just a 2-week period. Subjects in this study were trained using a real-time strategy game where texture discrimination is especially useful for identifying structures and characters at a glance. Some of

the differences in visual attention skill may come from the requirements of the genre, but there are still some general attributes that VGPs tend to share.

Long Term Video Game Use Effects

Although game players can be found across the age spectrum, adolescents, in particular, tend to spend the most time playing video games. During adolescence when the brain is still developing, extensive video gameplay over a long period of time may lead to structural changes. Kim et al. (2015) used fMRI scans to look at the frontal areas of the brain that develop during adolescence as saw greater plasticity of VGPs. This was particularly prominent in the inferior occipitofrontal fasciculus which is the white matter projection between the visual cortex and frontal lobe. Zhang et al. (2015) found that VGPs had significantly higher fractional anisotropy (FA) values which are associated with working memory areas related to attentional control, working memory, executive control, problem-solving. Similar to research that showed a greater capacity of AVGPs, this was correlated with faster reaction times on visual attention capacity tasks. As these studies do not directly prove that video game play improves these areas, it may be the case that individuals with natural improvements to these areas of the brain are better able to succeed and thus persist in playing video games.

Beyond the structural changes to developing brains, the effects on adolescent behavior have also been examined. The DSM-5 introduced internet gaming disorder (IGD) for the first time, sharing criteria with other addictive disorders. Buono et al. (2017) showed that while casual gamers (less than 5 hours per week) were motivated by the reinforcing positive rewards of games, individuals who played for more than 24 hours per week were more motivated by escape from daily stressors. As with most addictive disorders, the problem is dealt with through avoidance of responsibility. In a three-year longitudinal study, Gnambs et al. (2020) showed that

adolescents with intensive computer gaming habits tended to have lower grades but showed no loss in domain-specific competency. It is suggested that computer gaming behavior is regulated by school demands and that more time is spent during breaks when the attentional demand is low. This however would require greater impulsivity control which contrasts existing research by Gentile et al. (2012) that showed greater attentional and impulsivity issues in video game players, especially in an academic setting. This finding is however often bidirectional with individuals with attention problems often being drawn the video games as illustrated by individuals with ADHD that show high impulsiveness being more likely to play video games.

Conclusion

The overall trend of research on visual attention seems to point towards improvement from video game playing. Specifically, the capacity of visual attention seems the most subject to change, with other smaller improvements being seen in peripheral processing, and visual discrimination tasks. These improvements often come from similar in-game practice tasks, but do not seem to have an effect is in the remembering of visual information or the tracking of multiple objects. VGPs also seem to show greater development of brain regions associated with visual processing, but this may be due to natural differences as these individuals are also more likely to struggle with attentional deficits and impulsive behavior that may lead to video game addiction.

References

Appelbaum, L. G., Cain, M. S., Darling, E. F., & Mitroff, S. R. (2013). Action video game playing is associated with improved visual sensitivity, but not alterations in visual sensory memory. *Attention, Perception, & Psychophysics, 75(6),* 1161-1167. http://dx.doi.org/10.3758/s13414-013-0472-7

Boot, W. R., Kramer, A. F., Simons, D. J., Fabiani, M., & Gratton, G. (2008). The effects of video game playing on attention, memory, and executive control. *Acta Psychologica, 129*(3), 387-398. http://dx.doi.org/10.1016/j.actpsy.2008.09.005

Belchior, P., Marsiske, M., Sisco, S. M., Yam, A., Bavelier, D., Ball, K., & Mann, W. C. (2013). Video game training to improve selective visual attention in older adults. *Computers in Human Behavior, 29(4)*, 1318-1324. http://dx.doi.org/10.1016/j.chb.2013.01.034

Buono, Frank D., et al. "Measures of Behavioral Function Predict Duration of Video Game Play: Utilization of the Video Game Functional Assessment—Revised." *Journal of Behavioral Addictions* 6.4 (2017): 572-8. *ProQuest.* Web. 10 Sep. 2020.

Dale, Gillian, et al. "Cognitive Abilities of Action Video Game and Role-Playing Video Game Players: Data from a Massive Open Online Course." Psychology of Popular Media 9.3 (2020): 347-58. ProQuest. Web. 10 Sep. 2020.

Dobrowolski, P., Hanusz, K., Sobczyk, B., Skorko, M., & Wiatrow, A. (2015). Cognitive enhancement in video game players: The role of video game genre. *Computers in Human Behavior, 44*, 59-63. http://dx.doi.org/10.1016/j.chb.2014.11.051

Green, C. S., and Daphne Bavelier. Action Video Game Modifies Visual Selective Attention. *Nature* 423.6939 (2003): 534-7. ProQuest. Web. 10 Sep. 2020.

Gnambs, T., Stasielowicz, L., Wolter, I., & Appel, M. (2020). Do computer games jeopardize educational outcomes? A prospective study on gaming times and academic achievement. *Psychology of Popular Media., 9*(1), 69-82. http://dx.doi.org/10.1037/ppm0000204

Gentile, D. A., Swing, E. L., Lim, C. G., & Khoo, A. (2012). Video game playing, attention problems, and impulsiveness: Evidence of bidirectional causality. *Psychology of Popular Media Culture, 1*(1), 62–70. https://doi.org/10.1037/a0026969

Kim, Y., Kang, D., Kim, D., Kim, H., Sasaki, Y., & Watanabe, T. (2015). Real-time strategy video game experience and visual perceptual learning. *The Journal of Neuroscience, 35*(29), 10485-10492. http://dx.doi.org/10.1523/JNEUROSCI.3340-14.2015

Oei, A. C., & Patterson, M. D. (2013). Enhancing Cognition with Video Games: A Multiple Game Training Study. PLoS One, 8(3) http://dx.doi.org/10.1371/journal.pone.0058546

Zhang, Y., Du, G., Yang, Y., Qin, W., Li, X., & Zhang, Q. (2015). Higher integrity of the motor and visual pathways in long-term video game players. *Frontiers in Human Neuroscience,* http://dx.doi.org/10.3389/fnhum.2015.00098

Tables

Table 1

Literature Review

Study	Subjects	Test(s) used	Games/ Genres	Measures of Attention	Effects Found
Appelbaum et al. (2013)	31 AVGP 36 NVGP	Individual differences assessment for Likert scale of video game genre expertise Behavioral testing – Letters flashed in circle around fixation, then after variable delay red line pointing to desired response location	Action / platforming, FPS	Percentage of correct responses Delay between stimuli and desired response in Behavioral testing	Memory performance was higher for AVGP Improved perceptual sensitivity but no difference in iconic memory
Boot et al. (2008)	All Male 11 VGP 10 NVGP + longitudinal 82 NVGP	1 Functional Field of View Attentional Blink Enumeration Multiple Object Tracking Visual Short-term memory 2 Spatial 2-back Corsi block taping task Mental Rotation 3 Task Switching Tower of London Working memory operation span Ravens matrices	Medal of Honor Rise of Nations	1 Visual Attention 2 Spatial Processing and Memory 3 Executive Control	Large improvements to game specific tasks with practice Longitudinal NVGP did not show improvement to 1 2 or 3 tasks
Belchior et al. (2013)	58 NVGP aged 65-91 same sex (M) Education	Trained on MoH, UFOV, Tetris (placebo control) or non-contact for one week. Pretest / Posttest on UFOV task	Medal of Honor Tetris	UFOV (useful field of vision) Speed, Divided attention, selective attention	Improved visual selective attention in MoH and Tetris compared to non-contact. Unlike younger adults, Tetris had an effect. Likely because it was as challenging to learn for older adults (Gaming Literacy)
Buono et al. (2017)	453 VGP Screened out co-occurring disorders	VGFA-R 24 item survey	Any	Social Attention Escape (from daily stressors)	Positive relationship between social attention and escape

Study	Subjects	Test(s) used	Games/ Genres	Measures of Attention	Effects Found
				Tangible (desire for item or commodity) Sensory (visual and audio)	
Dale et al. (2020)	76 AVGP 77 NPGP 23 RPGP	Useful Field of View Multiple Object tracking	Action Role Playing	MOT Use attentional control refresh working memory.	RPGP can have the same effects as AVGP
Dobrowolski et al. (2015)	30 NVGP 30 FPS 30 RTS	Task switching Multiple object tracking Similarity ratings	FPS RTS	Reaction time Task switching cost Perceptual sensitivity	RTS players had fastest reaction times and better perceptual sensitivity Both VGP groups had less task switching cost
Gentile et al. (2012)	3034 Longitudinal	ADHD Self Report Barrett Impulsiveness scale Exam Scores	All		
Green and Daphne (2003)	Male VGP NVGP	Flanker Compatibility Enumeration Useful Field of View Attentional blink	Action FPS	Attentional Capacity	VGP larger capacity for attending to or ignoring distractor. Greater attentional capacity, spatial distribution, and ability to avoid 'bottlenecks' NVGP training improved scores
Gnambs et al. (2020)	3554 High school aged students	Survey 3 yrs longitudinal	RPG Skill games Other	Math and Reading competency	Lower grades in students with intensive computer gaming, but no loss in domain specific knowledge
Kim et al. (2015)	All Male 16 VGP 15 NVGP Same Age, Education,	Texture discrimination task 6 training sessions over 2 weeks	RTS	fMRI Accuracy and Response time to TDT	VGP had better performance on TDT but this gap decreased with training Found greater brain plasticity in Frontal areas of VGP
Oei and Patterson (2013)	75 NVGP	Attentional Blink Filter Task Visual Search	Hidden Object	Visual Search time	Action video games diminished the effects of attentional blink and

Study	Subjects	Test(s) used	Games/ Genres	Measures of Attention	Effects Found
		Complex Span	Memory Matrix Match-3 Action The sims	Accuracy in attentional blink Multiple object tracking	improved Multiple object tracking Memory Matrix and hidden object improved visual search
Zhang et al. (2015)	45 Total 28 VGP	Visual Attention network task MRI	Audition Dance battle, Crossfire, Need for speed, Warcraft,	Reaction time Fractional anisotropy (FA)	VGP had greater FA and faster reaction times

Note: VGP: Video Game Player. AVGP: Action Video Game Player. NVGP: Non-Video Game Player