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Action video game players' visual search advantage extends to biologically relevant stimuli

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ABSTRACT

Research investigating the effects of action video game experience on cognition has demonstrated a host of performance improvements on a variety of basic tasks. Given the prevailing evidence that these benefits result from efficient control of attentional processes, there has been growing interest in using action video games as a general tool to enhance everyday attentional control. However, to date, there is little evidence indicating that the benefits of action video game playing scale up to complex settings with socially meaningful stimuli — one of the fundamental components of our natural environment. The present experiment compared action video game player (AVGP) and non-video game player (NVGP) performance on an oculomotor capture task that presented participants with face stimuli. In addition, the expression of a distractor face was manipulated to assess if action video game experience modulated the effect of emotion. Results indicate that AVGPs experience less oculomotor capture than NVGPs; an effect that was not influenced by the emotional content depicted by distractor faces. It is noteworthy that this AVGP advantage emerged despite participants being unaware that the investigation had to do with video game playing, and participants being equivalent in their motivation and treatment of the task as a game. The results align with the notion that action video game experience is associated with superior attentional and oculomotor control, and provides evidence that these benefits can generalize to more complex and biologically relevant stimuli.

1. Introduction

Research investigating the effects of action video games, known for being fast paced and attentionally demanding, has demonstrated performance benefits across a variety of visual search paradigms. The earliest work in this area demonstrated reduced visuospatial reorienting costs when targets appeared at low probability locations in a stimulus detection paradigm (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994). The findings from this work provided an early account of possible attentional differences in AVGPs and NVGPs. Specifically, Greenfield et al. suggested that AVGPs are better able to allocate and divide selective attention thereby improving visual search performance. Research over the past decade has provided further evidence for a visual search advantage in AVGPs. For example, AVGPs outperform NVGPs on traditional visual search tasks (Castel, Pratt, & Drummond, 2005; Hubert-Wallander, Green, Sugarman, & Bavelier, 2011), useful-field of view tasks (Dye & Bavelier, 2010; Feng, Spence, & Pratt, 2007; Green & Bavelier, 2003, 2006a), flanker/load tasks (Dye, Green, & Bavelier, 2009; Green & Bavelier, 2003, 2006a; Xuemin & Bin, 2010, though see Irons, Remington, & McLean, 2011), distraction-based tasks (Chisholm, Hickey, Theeuwes, & Kingstone, 2010), and a change detection task (Clark, Fleck, & Mitroff, 2011). Collectively these findings have suggested that action video game experience provides players with enhanced control over the allocation of attentional resources (Hubert-Wallander, Green, & Bavelier, 2010), an effect that generalizes to superior oculomotor control (Chisholm & Kingstone, 2012, 2015; West, Al-Aidroos, & Pratt, 2013).

Despite the growing body of work on the effects of action video game experience, there has been little work investigating whether the cognitive benefits seen in the lab translate to more natural or complex contexts, with only a few notable exceptions. Gaspar et al. (2013) recently addressed this issue and failed to find an AVGP advantage in a more realistic street-crossing paradigm. By contrast, Franceschini et al. (2013) demonstrated that action video game training can yield improvements in reading performance in dyslexic individuals. Studies have also revealed that prior video game experience (not specific to action video games) is correlated with laparoscopic surgery performance (Rosenberg, Landsittel, & Averch, 2005; Rosser et al., 2007; Yule et al., 2011) and improvements on various military-based tasks (Gopher, Well, & Bareket, 1994; Kennedy, Bittner, & Jones, 1981; Lintern & Kennedy, 1984).

These investigations present encouraging results that action video game playing can positively affect performance in some complex

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contexts, however the vast majority of visual search studies have compared AVGP and NVGPs performance on traditional paradigms with very basic stimuli. Given the ubiquity of eye movements in everyday behaviour, one could argue that the demonstration that AVGPs outperform NVGPs on measures of oculomotor control (Chisholm & Kingstone, 2012, 2015; West et al., 2013) supports the prediction that the attentional effects of action video game playing will generalize to more complex contexts. Yet there is a wealth of recent evidence indicating that eye movement behaviour for social stimuli are very different compared to primitive stimulus features (e.g., Birmingham, Bischof, & Kingstone, 2009; Wu, Anderson, Bischof, & Kingstone, 2014). The present investigation examined whether the superior oculomotor control demonstrated by AVGPs generalizes to a situation composed of complex, biologically relevant stimuli, i.e., faces.

The biological importance of faces has been supported by neurophysiological evidence that has revealed a neural region, called the fusiform face area, that is preferentially biased for the processing of face information (Kanwisher, McDermott, & Chun, 1997; Kanwisher & Yovel, 2006). Behavioual evidence has also demonstrated that when viewing natural scenes that include other people, participants often are biased to attend to faces rather than other regions (Birmingham, Bischof, & Kingstone, 2008; Birmingham et al., 2009). Preferentially attending to faces would appear to serve an important function in social interactions as facial cues can provide insight into the emotional or cognitive state of others. This bias has led researchers to investigate whether committing attention towards faces operates in a purely bottom-up manner, giving rise to traditional attentional capture, or whether attending to faces is modulated by top-down attentional control. Although some evidence has been provided to suggest that faces do capture attention in a bottom-up manner (Brosch, Sander, & Scherer, 2007; Devue, Belopolsky, & Theeuwes, 2012; Langton, Law, Burton, & Schweinberger, 2008; Theeuwes & Van der Stigchel, 2006; Weaver & Lauwereyns, 2011), other evidence suggests that the prioritization of faces can be modulated by top-down control (Bindemann, Burton, Langton, Schweinberger, & Doherty, 2007; Horstmann, 2007; Ro, Russell, & Lavie, 2001). Despite the debate over the precise basis for the prioritization of face stimuli, collectively, the evidence converges on the conclusion that faces are processed preferentially by the attentional system.

Given that AVGPs are better able to resist oculomotor capture from a basic stimulus that appeared as an abrupt onset (i.e., coloured circle; Chisholm & Kingstone, 2012, 2015), the present study sought to investigate whether this advantage would extend to a context that displays face stimuli. Therefore, in the present investigation, we had participants complete an oculomotor capture paradigm with schematic face stimuli. As faces possess a unique status within the attentional system, a number of outcomes are possible. One could argue that action video game playing presents a context where players are trained to assign meaning to basic visual stimuli (e.g., shapes on a map representing other players, in-game cues warning players of upcoming events). By being adept at attaching meaning to generally meaningless stimuli, this could provide an account for the advantage AVGPs experience in visual search performance on tasks with simple stimuli. As faces should be equally meaningful for both AVGPs and NVGPs, one possible outcome of the present investigation is that the AVGP advantage will be eliminated when presented with biologically relevant and socially meaningful stimuli. By contrast, a second possible outcome emerges from the fact that coupling a face stimulus, which is already prioritized by the attentional system, with an abrupt onset status may make distractor inhibition particularly difficult to achieve. As previous work has reported AVGP outperforming NVGP under more demanding circumstances (e.g., Green & Bavelier, 2003, 2006a; Hubert-Wallander et al., 2011), a divergent possibility is that including faces may accentuate the AVGP advantage over NVGPs. A third possibility is that face stimuli represent a special class of stimuli and will thus have a significant impact on overall performance for all individuals but not interact with the AVGP advantage, instead giving rise to an equivalent increase in oculomotor capture across groups while maintaining an AVGP advantage.

It is important to note another manipulation that was included in addition to the introduction of face stimuli. When an abrupt onset face appeared in the display, it could depict either a neutral, happy, or inverted happy face. Much of the face processing literature has revealed particular biases for emotional faces (Fox et al., 2000; Hodsoll, Viding, & Lavie, 2011; Notebaert, Crombez, Van Damme, De Houwer, & Theeuwes, 2011; Vuilleumier & Schwartz, 2001; Williams, Moss, Bradshaw, & Mattingley, 2005); therefore, this manipulation presents a context where the difficulty of distractor inhibition may vary as a function of changes in emotion, thus presenting an additional test of the predictions provided above. For example this manipulation allowed for the assessment of the possible influence of emotional content on AVGP performance. Currently it is unclear how emotional information may differentially affect AVGPs search performance compared to NVGPs. One study demonstrated that experience with the violent content typically present in action video games was associated with a reduced happy-face advantage (Kirita & Endo, 1995; Leppänen & Hietanen, 2004; Leppänen, Tenhunen, & Hietanen, 2003) when participants had to detect whether a neutral face changed to either a happy or angry face (Kirsh & Mounts, 2007). More recent neurophysiological evidence has also indicated that experience with action video games, again presumably due to their violent nature, is associated with reduced attention to happy faces (Bailey & West, 2013). Thus, if AVGPs are particularly insensitive to positive affect, then it is possible that the ability of a distractor to capture AVGPs' attention will be especially weak when a happy face distractor is presented relative to when a neutral or inverted face distractor is presented. Or to put it differently, the AVGP advantage for avoiding capture by irrelevant distractors will be accentuated for happy faces.

2. Methods

2.1. Participants

Data from 32 undergraduate male participants, evenly split into AVGP (18–23 years old, mean: 20.4) and NVGP (18–27 years old, mean: 22.3) groups, recruited from the University of British Columbia, are reported. Participants who reported playing a minimum of 3 h per week of action video games over the last six months were defined as AVGPs and NVGPs were those who reported little to no action video game playing over the past six months. The AVGPs sample reported an average of approximately 8.2 h of action games per week (e.g., *Counter-Strike: Global Offense, Team Fortress 2, Battlefield 3, Call of Duty*). NVGPs reported playing no action video games but did play an average of approximately 4.4[1] hours of non-action games per week. In response to recent concerns regarding the potential of introducing demand characteristics when actively recruiting experts and novices (Boot, Blakely, & Simons, 2011; Kristjánsson, 2013), all participants were recruited covertly. Specifically, prior to using the University of British Columbia's human subject pool, all potential participants completed an extensive pre-screening questionnaire, which included questions relating to their experience with video games. Only participants who met the AVGP or NVGP criteria listed above were eligible and able to sign-up to participate in the experiment. Participants were not aware of this eligibility restriction prior to participating, no mention of the video game nature of the experiment was provided in the advertisement, and additional self-reported measures were collected only after completing the task. Participants who were eligible to participate

[1] This relatively higher value is a result of 3 NVGPs who reported playing a lot (>10 h/week) of a specific strategy game (*League of Legends, Starcraft II*). Although previous work demonstrated improvements in executive function in an elderly sample as a result of strategy video game training, no benefits on visuospatial attention tasks were observed (Basak, Boot, Voss, & Kramer, 2008).