Journal of Cognitive Enhancement (2019) 3:104–110
https://doi.org/10.1007/s41465-018-0087-y

BRIEF REPORT

Simon-Task Reveals Balanced Visuomotor Control in Experienced Video-Game Players

Andrew James Latham[1,2] · **Christine Westermann**[3,4] · **Lucy L. M. Patston**[3,4] · **Nathan A. Ryckman**[3,4] · **Lynette J. Tippett**[3,4]

Received: 20 February 2018 / Accepted: 26 June 2018 / Published online: 2 July 2018

Abstract

Both short and long-term video-game play may result in superior performance on visual and attentional tasks. To further these findings, we compared the performance of experienced male video-game players (*VGPs*) and non-VGPs on a Simon-task. Experienced-VGPs began playing before the age of 10, had a minimum of 8 years of experience and a minimum play time of over 20 h per week over the past 6 months. Our results reveal a significantly reduced Simon-effect in experienced-VGPs relative to non-VGPs. However, this was true only for the right-responses, which typically show a greater Simon-effect than left-responses. In addition, experienced-VGPs demonstrated significantly quicker reaction times and more balanced left-versus-right-hand performance than non-VGPs. Our results suggest that experienced-VGPs can resolve response-selection conflicts more rapidly for right-responses than non-VGPs, and this may in part be underpinned by improved bimanual motor control.

Keywords Video-games · Simon-task · Simon-effect · Laterality · Visuomotor control · Visuospatial attention

Action video-games place incredible demands on players' visual and cognitive abilities. Numerous sensory objects must be appraised simultaneously as relevant or irrelevant to players' in-game goals and responded to with quick, precise bimanual movements. Action video-games are not just populated with static objects, but dynamic avatars under the control of other video-game players (*VGP*s). Experimental evidence demonstrates video-game play may facilitate superior perceptual and cognitive capabilities that generalise beyond the context of video-game play (e.g. Chisholm et al. 2010; Li et al. 2010; Sungur and Boduroglu 2012; for review, see Latham et al. 2013a) although not all studies have found this (e.g. Gobet et al. 2014; Murphy and Spencer 2009; van Ravenzwaaij et al. 2014). Even short periods of video-game play by non-VGPs can result in improved performance in the same direction as VGPs, lasting for at least 5 months after video-game play has ceased (Feng et al. 2007; Spence et al. 2009). Video-game play has also been found to lead to superior performance on response-conflict tasks such as the Stroop and Flanker tasks (e.g. Goldstein et al. 1997; Green and Bavelier 2003). However, contrary to this, Irons et al. (2011) failed to find differences between VGPs and non-VGPs on two flanker tasks. Further, Bailey et al. (2010) have reported evidence that VGPs possess worse proactive cognitive control than non-VGPs.

There are a number of reasons why the VGP literature might contain numerous inconsistent findings. For one, differences in methodology, especially in what constitutes video-game expertise, mean sample populations are not entirely comparable between studies (Latham et al. 2013b). Further, the effects of video-game training might be observable in only a narrow range of cognitive domains and tasks (for review, see Oei and Patterson 2014). However, VGPs might show a narrow range of improvements for another *interesting* reason, as developing expertise in humans has been associated with differences in the lateralization of cognitive function (e.g. Latham et al. 2014; Patston et al. 2006; Patston et al. 2007). In the following study, we examine the performance of

✉ Andrew James Latham
andrew.latham@sydney.edu.au

[1] Department of Philosophy, The University of Sydney, Quadrangle A14, Sydney, NSW 2006, Australia

[2] Brain and Mind Centre, The University of Sydney, Sydney, Australia

[3] School of Psychology, The University of Auckland, Auckland, New Zealand

[4] Centre for Brain Research, The University of Auckland, Auckland, New Zealand

experienced-VGPs on a Simon-task, to further investigate the association between experienced action VGPs and these cognitive abilities. We report for the first time that experienced-VGPs demonstrate a reduced Simon-effect *for right responses only*, relative to non-VGPs.

The Simon-task (Simon and Rudell 1967) has been extensively used to investigate stimulus-response (*S-R*) compatibility effects on a variety of performance measures (for review, see Proctor and Vu 2006). In a standard experimental trial, participants are presented with a target stimuli containing response information (i.e. left-hand; right-hand) at some spatial location (i.e. left side-of-space; right side-of-space). Participants are asked to ignore the position of the stimuli and react only to the response information. Despite the spatial information being task-irrelevant, participants consistently perform more quickly on congruent (e.g. left side-of-space/left-hand) compared to incongruent (e.g. left side-of-space/right-hand) trials. This slowing of reaction time (*RT*) is the Simon-effect. It reflects the performance cost of an incongruent S-R contingency and is calculated by subtracting congruent trials from incongruent trials.

Two mechanisms, together, have been suggested to underlie the Simon-effect. First, attention-orientation toward a target stimuli's location generates a spatial code for that location (De Jong et al. 1994; Wascher et al. 2001; for alternative account see Hommel 1993). Second, despite being task irrelevant, this spatial code generates a response code toward the spatial location of the target stimuli (Proctor et al. 1995; Spironelli et al. 2006). When the required response to a stimulus and the response generated by its spatial location are incongruent, a conflict occurs during response-selection. This is what underlies the observed Simon-effect.

To our knowledge, only two studies have investigated the relationship between video-game play and the Simon-effect with mixed results. First, Bialystok (2006) investigated the relationship between video-game expertise and frequency of play on the Simon-effect. She found that while VGPs had significantly quicker RTs to visual stimuli relative to non-VGPs, there was no significant between-group difference in the Simon-effect. It is important to note that video-game expertise and frequency of play was only assessed using a self-report 10-point Likert scale. Those who reported a score of six and above in both expertise and frequency of play were classified as 'high'-VGPs. All remaining participants were classified as 'low'-VGPs. Unfortunately with this method of classification, we cannot ascertain how different VGPs are from their non-VGP counterparts, or whether those participants classified as VGPs possess the expertise and frequency of play required shaping executive processes (Latham et al. 2013b).

More recently, a second study on this topic was conducted by Hutchinson and colleagues, in which they investigated the effect of video-game training on the Simon-effect in non-VGPs (Hutchinson et al. 2016). Seemingly in contrast to Bialystok, they found that 10 1-h sessions of action video-game training was able to reduce the Simon-effect in non-VGPs. Conversely, non-VGPs who played a non-action video-game, or no video-games at all, showed no reduced Simon-effect.

We predicted that extensive video-game experience should also be associated with quicker response conflict resolution in the Simon-task, resulting in a reduced Simon-effect in experienced-VGPs relative to non-VGPs. If Hutchinson et al. (2016) are right that only 10 1-h sessions of action video-game training can reduce the Simon-effect in non-VGPs then experienced-VGPs should be expected to demonstrate a reduced Simon-effect relative to non-VGPs. Further, as we reported earlier VGPs have demonstrated superior performance on other closely related conflict-oriented tasks in the past (i.e. Stroop and Flanker).

An often overlooked aspect of the Simon-task that may be modified by video-game play is the asymmetry of the Simon-effect. The Simon-effect is typically larger for right-responses than left-responses as a result of the lateralization of cognitive function (Spironelli et al. 2009; for review see Tagliabue et al. 2007). Neurotypical right-handers typically show quicker performance when using their right-hand relative to their left-hand and superior performance to stimuli in their left-visual-field relative to their right-visual-field. These patterns of performance are thought to reflect the lateralized dominance of motor initiation to left-hemisphere motor and parietal regions (Rushworth et al. 2003; Schluter et al. 1998) and visuospatial attention to the right parietal cortex (e.g. Oliveri et al. 2004; de Schotten et al. 2011).

Developing expertise in humans can be accompanied by changes to the lateralization of cognitive function. For example, expert musicians show superior performance on visuospatial tasks (Brochard et al. 2004) and this has been proposed to result from the reduced lateralized dominance of visuospatial attention for the right-hemisphere of the brain (Patston et al. 2006, 2007). Recent results have also shown that VGPs also may show reduced right-hemisphere dominance for visuospatial attention, with a reduced leftward response bias in the line-bisection task (Latham et al. 2014). While video-game play and musical performance are distinct activities, they share key similarities. Both require the translation of complex visual cues into precise, rapid bimanual movements, and often begin during early childhood and continue through adolescence when the brain is continuing to develop and at its most malleable.

Typically when playing a video-game, each VGP's hand controls an independent element of video-game performance. For example, when playing a first-person shooter, the left-hand controls a player's movement and the right-hand controls their vision. For VGPs, not only are delays in response-selection resulting from the Simon-effect detrimental to in-game success, but so too are performance biases brought about by differential capabilities with each hand and for each visual-field. These biases may lead to a breakdown in the coordination required to maintain competent in-game control, or introduce predictable biases into performance that might be exploitable. As a result, the demands of video-game play may drive experienced-VGPs to develop more balanced performance with each hand irrespective of the spatial location in which stimuli appear.

Thus, in the present study, we assess the impact of extensive video-game play on performance asymmetries in the Simon-task. If the laterality of perceptual and cognitive functions can be shaped by video-game play then experienced-VGPs will show a reduced asymmetry between left-and-right Simon-effect responses whereas non-VGPs will continue to show an asymmetry.

Method

Participants

Sixteen male experienced-VGPs and 16 male non-VGPs participated in the study. Participants were recruited through public advertisement and research participation scheme at the School of Psychology in the University of Auckland. Participants were not briefed on the purpose of the study and were completely naïve to the study's hypothesis. VGPs were defined as experienced if they began playing before the age of 13 ($M = 7$, $SE = .60$, Min. = 5, Max = 13), had a minimum 8 years of experience ($M = 17$, $SE = 1.28$, Min. = 9, Max. = 27), and a minimum play time of 20 h per week over the previous 6 months ($M = 35$, $SE = 4.69$, Min. = 20, Max. = 90). Accepted video-game genres were restricted to first-person shooters, multiplayer online battle arenas, real-time strategy games, and massively multiplayer online role-playing games. Success in these video-game genres requires rapid bimanual movements in response to complex in-game visual cues. Non-VGPs were required to little-to-no video-game experience (maximum of 1.5 years of video-game play experience). None of our non-VGPs reported any video-game experience. Individuals were excluded if they were left-handed or had received *any* music lessons or musical training. Females were eligible to participate in the experiment but none met the experienced-VGP criteria.

There were no statistical differences between experienced-VGPs and non-VGPs for age (VGPs: $M = 24$, $SE = 1.11$; non-VGPs: 25, $SE = 1.39$), years of education (VGPs: $M = 15$, $SE = 2.33$; non-VGPs: $M = 16$, $SE = 1.97$), or handedness as established by the Edinburgh Handedness Inventory (VGPs: $M = 91$, $SE = 2.14$; non-VGPs: $M = 87.19$, $SE = 3.89$; Oldfield 1971).

Ethical approval for this study was obtained from the University of Auckland Human Participants Ethics Committee. Informed written consent was obtained from all participants prior to testing. All participants were naïve to the study's hypotheses. The experiment was performed in a dedicated behavioural testing lab within the School of Psychology at The University of Auckland.

Materials and Procedure

Participants were seated 57 cm away from the monitor (a 22-in. Samsung computer monitor, 1920 × 1080 pixel resolution, 60 Hz refresh rate). The procedure was run on E-Prime. Stimuli appeared either in the left-visual-field or right-visual-field with their midpoint located 7° from a central fixation cross. Participants were instructed to maintain their gaze on the central fixation cross throughout the experiment. Each trial was separated by a random inter-trial interval between 1200 and 1400 ms. Stimuli were white arrows presented on a black background for 200 ms. Arrows were 1° in length and .6° in height. Following each presentation, participants had up to 1000 ms to make a response. On trials where the arrowhead faced left, participants were instructed to respond by pushing the 'D'-key with their left index-finger and when the arrowhead faced right, participants were instructed to respond by pushing the 'L'-key with their right index-finger. Participants were given a practice block of 16 trials and completed a single experimental block of 400 randomised experimental trials, 100 of each of four experimental conditions: left-hand/ left-visual-field, right-hand/right-visual-field, left-hand/right-visual-field, and right-hand/left-visual-field.

Analyses

Correct responses were those key presses occurring after stimulus presentation that matched the response required by the stimulus arrowhead. RTs faster than 150 ms were considered anticipatory responses and excluded from analyses (< 1%).[1] RTs were analysed using a split plot analysis of variance (ANOVA) with a between-subject factor of group (experienced-VGPs, non-VGPs) and within-subject factors of response hand (left-hand, right-hand) and stimulus visual-field (left-visual-field, right-visual-field). The Simon-effect is represented by the two-way interaction between the within-subjects factors hand and visual-field. Group differences in Simon-effect are represented by the three-way interaction between group, hand and visual-field.

[1] In order to assess the robustness of our findings we also reran the analyses excluding all RTs >2SD above the mean. Excluding these RTs from the analyses had *no* impact on our reported results. We would like to thank an anonymous reviewer for this suggestion.

Results

Percentage accuracy for both experienced-VGPs ($M = 90.81$, $SE = .87$) and non-VGPs ($M = 91.94$, $SE = 1.18$) was high and did not differ significantly, $F(1,30) = .589$, $p = .449$. Subsequent analyses were performed on correct trials only, which correctly represented performance of the Simon-task.

Analysis of RT data revealed significant main effects of group ($F(1,30) = 9.081$), $p = .005$, and visual-field ($F(1,30) = 5.474$), $p = .026$. RTs were significantly quicker for experienced-VGPs ($M = 417.52$, $SE = 12.85$) than non-VGPs ($M = 472.22$, $SE = 12.84$). RTs were slightly slower for left-visual-field stimuli ($M = 447.24$, $SE = 8.78$) than right-visual-field stimuli ($M = 442.29$, $SE = 9.45$).

There was a significant two-way interaction between group and hand ($F(1,30) = 4.998$), $p = .033$, and hand and visual-field (Simon-effect; $F(1,30) = 57.485$), $p < .001$. Consistent with our predictions, experienced-VGPs were not only significantly quicker than non-VGPers, they responded just as quickly with their left-hand as their right-hand, $p = .729$. Non-VGPs displayed an asymmetry in hand performance, responding significantly quicker with their right-hand than their left-hand, $p = .009$, (see Fig. 1).

Consistent with the Simon-effect, RTs with the left-hand were significantly quicker to left-visual-field stimuli ($M = 437.01$, $SE = 8.81$) than right-visual-field stimuli ($M = 460.17$, $SE = 10.88$), $p < .001$, and RTs with the right-hand were significantly quicker to right-visual-field stimuli ($M = 424.83$, $SE = 8.85$) than left-visual-field stimuli ($M = 457.47$, $SE = 9.54$), $p < .001$. Stimuli in the left-visual-field were responded to significantly quicker with the left-hand than right-hand, $p < .001$, and right-visual-field stimuli were responded to significantly quicker with the right-hand than left-hand, $p < .001$.

Importantly, there was a significant three-way interaction between group, hand and visual-field (group and Simon-effect; $F(1,30) = 4.355$), $p = .045$. When examining responses to stimuli presented in the left-visual-field only (see Fig. 2), there was a significant main effect of group ($p = .002$) and a significant main effect of hand ($p = .002$), consistent with the Simon-effect, but no significant hand by group interaction ($p = .731$). In contrast, when examining responses to stimuli presented in the right-visual-field only, there were significant main effects of group ($p = .011$) and hand ($p < .001$), but also a significant hand by group interaction ($p = .006$). While there was no significant difference between the two groups when responding to right-visual-field stimuli with their right-hand, the non-VGPs showed a greater degree of slowing when responding to right-visual-field stimuli with their left-hand, relative to the experienced-VGPs. In other words, experienced-VGPs showed a significantly reduced Simon-effect to stimuli presented in their right-visual-field (see Fig. 2).

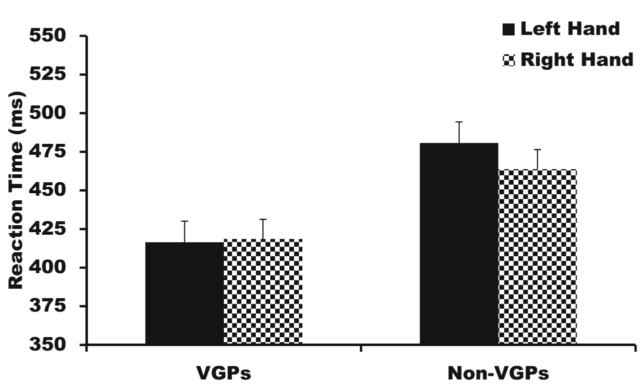

Fig. 1 Mean reaction time by hand used for experienced-VGPs and non-VGPs. Error bars represent standard error

Discussion

In this study, we examined the relationship between extensive video-game play and the Simon-effect. Consistent with Hutchinson et al. (2016), our experienced-VGPs displayed a significantly reduced Simon-effect relative to non-VGPs. We also examined the relationship between extensive video-game play and asymmetry in the Simon-effect. It has been repeatedly shown that the Simon-effect is typically larger for right-responses than for left-responses (Spironelli, et al. 2009, for review see Tagliabue et al. 2007). Our results show for the first time that only the Simon-effect for right-responses is significantly reduced in experienced-VGPs.

One contributor to the asymmetry in the Simon-effect is neurotypical right-handers quicker performance with their right-hand relative to their left-hand. The non-VGPs in this study produced significantly quicker RTs with their right-hand, relative to their left-hand. However, consistent with our predictions, experienced-VGPs showed no asymmetry for hand performance, with no difference in RTs between hands. Experienced-VGPs also produced quicker RTs with both hands relative to non-VGPs (e.g. Green and Bavelier 2003; Sungur and Boduroglu 2012). Action video-games require players to make quick time-pressured bimanual responses in response to complex in-game cues. Failure to make the correct response quickly often results in failure. Similarly, differential hand performance can adversely impact the player's in-game control and introduce biases into performance that can be exploited by other players. It is possible the ability of experienced-VGPs to make quicker responses with both hands to visual stimuli is the result of prolonged training under these conditions. However, future training-studies are required to test this hypothesis.

Another contributor to the asymmetry in the Simon-effect is neurotypical right-handers superior performance for stimuli in their left-visual-field relative to right-visual-field (e.g. Oliveri et al. 2004; de Schotten et al. 2011). Surprisingly our

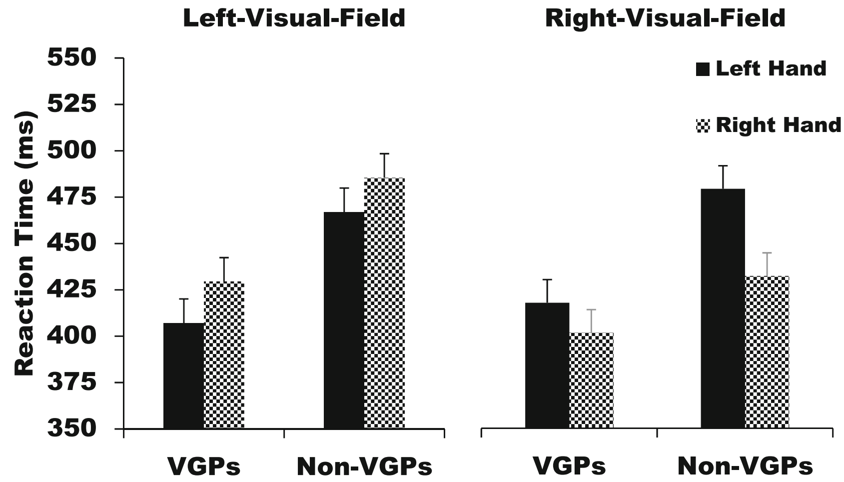

Fig. 2 Mean RT by hand used for left-visual-field and right-visual-field for experienced-VGPs and non-VGPs. Error bars represent standard error

results failed to find any left-visual-field performance bias. Instead, both experienced-VGPs and non-VGPs performed slightly better in the right-visual-field. While the performance of experienced-VGPs was consistent with previous research (e.g. Latham et al. 2013c, 2014), the performance of non-VGPs performance was not. This might indicate the left-visual-field performance bias is not entirely typical of the general population. The non-VGPs in this study lacked *any* video-game experience, had no formal musical training and were well-educated. It is possible that individuals in this age-band with no video-game experience or musical training comprise a special sub-population in their own right. Future research using non-VGPs should consider characterising this sample in more detail, in order to uncover what factors might be contributing to the presentation of various performance biases.

Consistent with previous Simon-task research (e.g. Simon and Rudell 1967; Spironelli et al. 2006) performance in both groups was superior when the required response to the stimuli and its spatial location were congruent and not incongruent. While the stimuli's spatial location is task irrelevant, it automatically generates a response code for that same direction. When this automatically generated response code differs from the required response code, a conflict occurs and response-selection must be made. In the current study, experienced-VGPs demonstrated a smaller Simon-effect than non-VGPs for right-responses. This suggests the response-selection conflict associated with these responses might be more rapidly resolved by experienced-VGPs.

A significant aspect of the Simon-effect finding in experienced-VGPs is it suggests superior performance by experienced-VGPs is not just the result of quicker responding to visual cues. Instead, in the context of right-responses, experienced-VGPs might be able to better screen out the response code generated by the stimuli's spatial location on the screen, or prevent it from being activated at all. It might appear strange there was no reduction in the Simon-effect for left-responses. As noted earlier, differential performance might adversely impact experienced-VGPs as it introduces biases into their performance that can be exploited. The reduction in the Simon-effect for right-responses only results in a more balanced Simon-effect in experienced-VGPs. Once again, it is possible this could be the result of prolonged training under these conditions, but future training-studies are required to test this hypothesis.

The reduced Simon-effect for right-responses shown by the experienced-VGPs in our study is in contrast to the findings of Bialystok (2006). The lack of demonstrable video-game experience of Bialystok's VGPs may explain why they did not observe the same result. In the present study, we recruited experienced-VGPs to examine the impact of extensive video-game play on the Simon-task and asymmetry in the Simon-effect. VGPs were considered experienced if they began playing before the age of 10, had a minimum 8 years of experience, and were required to have a minimum play time of 20 h per week over the last 6 months. *All* experienced-VGPs recruited into this study would have met the criteria to be included as VGPs in the majority of reported VGP studies, which require comparable—or fewer—hours of game-play (e.g. Chisholm et al. 2010; Li et al. 2010). However, many VGPs recruited for those studies would not meet our criteria for experienced-VGPs.

It is possible that the enhanced performance of the experienced-VGPs, as with all expertise-related research, is the result of some pre-existing characteristic rather than extensive task training/performance (for review targeted at video-game expertise see Boot et al. 2011). However, as reported earlier, 10 1-h sessions of action video-game play training appears to improve Simon-task performance in the same direction as our experienced-VGPs (Hutchinson et al. 2016). Further, studies have shown the benefits of these small periods of video-game play can be long-lasting (Feng et al. 2007; Spence et al. 2009), though it is rare to see these benefits generalise to other cognitive domains and tasks (for review see Oei and Patterson 2014). Together, this suggests it is possible that a predisposition for video-game play, while perhaps sufficient, is not necessary to alter cognitive performance. Instead video-game experience, under certain circumstances, might generalise as superior performance in a variety of tasks.

In summary, success in action video-game play requires players to make quick time-pressured bimanual responses in response to complex in-game visual cues, and the ability to rapidly resolve response-selection conflicts that arise from incongruent S-R contingencies. The balanced left-versus-right-hand performance and smaller Simon-effect for right-responses exhibited by experienced-VGPs in this study might be the result of extensive training under these conditions. However, future training-studies are required to test these hypotheses.

Compliance with Ethical Standards

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Bailey, K., West, R., & Anderson, C. A. (2010). A negative association between video game experience and proactive cognitive control. *Psychophysiology, 47*(1), 34–42.

Bialystok, E. (2006). Effect of bilingualism and compute video game experience on the Simon task. *Canadian Journal of Experimental Psychology, 60*, 68–79.

Boot, W. R., Blakely, D. P., & Simons, D. J. (2011). Do action video games improve perception and cognition? *Frontiers in Psychology, 2*, 226.

Brochard, R., Dufour, A., & Despres, O. (2004). Effect of musical expertise on visuospatial abilities: Evidence from reaction times and mental imagery. *Brain and Cognition, 54*, 103–109.

Chisholm, J. D., Hickey, C., Theeuwes, J., & Kingstone, A. (2010). Reduced attentional capture in action video game players. *Attention, Perception and Psychophysics, 72*, 667–671.

De Jong, R., Liang, C. C., & Lauber, E. (1994). Conditional and unconditional automacity: A dual-process model of effects of spatial stimulus-response correspondence. *Journal of Experimental Psychology: Human Perceptual Performance, 21*, 837–854.

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender difference in spatial cognition. *Psychological Science, 18*(10), 850–855.

Gobet, F., Johnston, S. J., Ferrufino, G., Johnston, M., Jones, M. B., Molyneux, A., Terzis, A., & Weeden, L. (2014). "No level up!": No effects of video game specialization and expertise on cognitive performance. *Frontiers in Psychology, 5*, 1337.

Goldstein, J. H., Cajko, L., Oosterbroek, M., Michielsen, M., van Houten, O., & Salverda, F. (1997). Video games and the elderly. *Social Behavior and Personality, 25*, 345–352.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*(6939), 534–537.

Hommel, B. (1993). The role of attention for the Simon effect. *Psychological Research, 55*, 208–221.

Hutchinson, C. V., Barrett, D. J. K., Nitka, A., & Raynes, K. (2016). Action video game training reduces the Simon effect. *Psychonomic Bulletin and Review, 23*, 587–592.

Irons, J. L., Remington, R. W., & McLean, J. P. (2011). Not so fast, rethinking the effects of action video games on attentional capacity. *Australia Journal of Psychology, 63*(4), 224–231.

Latham, A. J., Patston, L. L. M., & Tippett, L. J. (2013a). The virtual brain: 30 years of video-game play and cognitive abilities. *Frontiers in Psychology, 4*, 629.

Latham, A. J., Patston, L. L. M., & Tippett, L. J. (2013b). Just how expert are "expert" video-game players? Assessing the experience and expertise of video-game players across "action" video-game genres. *Frontiers in Psychology, 4*, 941.

Latham, A. J., Patston, L. L. M., & Tippett, L. J. (2014). The precision of experience action video-game players: Line bisection reveals reduced leftward response bias. *Attention, Perception, & Psychophysics, 76*(8), 2193–2198.

Latham, A. J., Patston, L. L. M., Westermann, C., Kirk, I. J., & Tippett, L. J. (2013c). Earlier visual N1 latencies in expert video-game players: A temporal basis of enhanced visuospatial performance? *PLoS One, 8*(9), e75231.

Li, R., Polat, U., Scalzo, F., & Bavelier, D. (2010). Reducing backward masking through action game training. *Journal of Vision, 10*(14), 1–13.

Murphy, K., & Spencer, A. (2009). Playing video games does not make for better visual attention skills. *Journal of Articles in Support of the Null Hypothesis, 6*(1), 1–20.

Oei, A. C., & Patterson, M. D. (2014). Are videogame training gains specific or general? *Frontiers in Systems Neuroscience, 8*, 54.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9*, 97–113.

Oliveri, M., Rausei, V., Koch, G., Torriero, S., Turriziani, P., & Caltagirone, C. (2004). Overestimation of numerical distances in the left side of space. *Neurology, 63*, 2139–2141.

Patston, L. L. M., Corballis, M. C., Hogg, S. L., & Tippett, L. J. (2006). The neglect of musicians: Line bisection reveals an opposite bias. *Psychological Science, 17*(12), 1029–1031.

Patston, L. L. M., Hogg, S. L., & Tippett, L. J. (2007). Attention in musicians is more bilateral than in non-musicians. *Laterality, 12*(3), 262–272.

Proctor, R. W., Lu, C. H., Wang, H., & Dutta, A. (1995). Activation of response codes by relevant and irrelevant stimulus information. *Acta Psychologica, 90*, 275–286.

Proctor, R. W., & Vu, K. P. L. (2006). *Stimulus-response compatibility principles. Data, theory, and application*. Boca Raton: CRC Press, Taylor & Francis Group.

van Ravenzwaaij, D., Boekel, W., Forstmann, B. U., Ratcliff, R., & Wagenmakers, E.-J. (2014). Action video games do not improve the speed of information processing in simple perceptual tasks. *Journal of Experimental Psychology: General, 143*(5), 1794–1805.

Rushworth, M. F., Johansen-Berg, H., Gobel, S. M., & Devlin, J. T. (2003). The left parietal and premotor cortices: Motor attention and selection. *Neuroimage, 20*, 98–100.

Schluter, N. D., Rushworth, M. F. S., Passingham, R. E., & Mills, K. R. (1998). Temporary interference in human lateral premotor cortex suggests dominance for the selection of movements. A study using transcranial magnetic stimulation. *Brain, 121*, 785–799.

de Schotten, M. T., Dell'Acqua, F., Forkel, S. J., Simmons, A., Vergani, F., Murphy, D. G. M., & Catani, M. (2011). A lateralized brain network for visuospatial attention. *Nature Neuroscience, 14*, 1245–1246.

Simon, J. R., & Rudell, A. P. (1967). Auditory S-R compatibility: The effect of an irrelevant cue on information processing. *Journal of Applied Psychology, 51*, 300–304.

Spence, I., Yu, J. J., Feng, J., & Marshman, J. (2009). Women match men when learning a spatial skill. *Journal of Experimental Psychology: Learning, Memory and Cognition, 35*(4), 1097–1103.

Spironelli, C., Tagliabue, M., & Angrilli, A. (2006). Asymmetrical hemispheric EEG activation evoked by stimulus position during Simon task. *Neuroscience Letters, 399*, 215–219.

Spironelli, C., Tagliabue, M., & Umilta, C. (2009). Response selection and attention orienting: A computational model of Simon effect asymmetries. *Experimental Psychology, 56,* 274–282.

Sungur, H., & Boduroglu, A. (2012). Action video game players form more detailed representation of objects. *Acta Psychologica, 139*(2), 327–334.

Tagliabue, M., Vidotto, G., Zorzi, M., Umiltà, C., Altoè, G., Treccani, B., et al. (2007). The measurement of left/right asymmetries in the Simon effect: A fine grained analysis. *Behavioral Research Methods, 39*, 50–61.

Wascher, E., Schatz, U., Kuder, T., & Verleger, R. (2001). Validity and boundary condition of automatic response activation in the Simon task. *Journal of Experimental Psychology: Human Perceptual Performance, 27*, 731–751.