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What is This?

Are Gamers Better Crossers? An Examination of Action Video Game Experience and Dual Task Effects in a Simulated Street Crossing Task

John G. Gaspar, University of Illinois Urbana-Champaign, Urbana, Illinois, USA, **Mark B. Neider**, University of Central Florida, Orlando, Florida, USA, and **James A. Crowell**, **Aubrey Lutz**, **Henry Kaczmarski**, and **Arthur F. Kramer**, University of Illinois Urbana-Champaign, Urbana, Illinois, USA

Objective: A high-fidelity street crossing simulator was used to test the hypothesis that experienced action video game players are less vulnerable than nongamers to dual task costs in complex tasks.

Background: Previous research has shown that action video game players outperform nonplayers on many single task measures of perception and attention. It is unclear, however, whether action video game players outperform nonplayers in complex, divided attention tasks.

Method: Experienced action video game players and nongamers completed a street crossing task in a high-fidelity simulator. Participants walked on a manual treadmill to cross the street. During some crossings, a cognitively demanding working memory task was added.

Results: Dividing attention resulted in more collisions and increased decision making time. Of importance, these dual task costs were equivalent for the action video game players and the nongamers.

Conclusion: These results suggest that action video game players are equally susceptible to the costs of dividing attention in a complex task.

Application: Perceptual and attentional benefits associated with action video game experience may not translate to performance benefits in complex, real-world tasks.

Keywords: video games, dual task performance, pedestrian safety, distraction

Address correspondence to John G. Gaspar, University of Illinois Urbana-Champaign, 405 N. Mathews, Urbana, IL 61801, USA; jgaspar2@illinois.edu.

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INTRODUCTION

With the increasing accessibility of technology, we are more often asked to divide our attention to accommodate competing demands. Imagine walking down a busy street, for instance, while talking on a cell phone; one would have to monitor surrounding pedestrians and vehicles, maintain balance and gait, and devote attention to the conversation. Dividing attention between two or more tasks concurrently generally results in degraded performance on one or both tasks, as compared to performing each task separately (e.g., Pashler, 1984). According to a resource view of attention, such dual task costs reflect the extent to which the tasks compete for shared resources; as resource capacity becomes increasingly strained, task performance declines (Kahneman, 1973; Wickens, 1991).

Dual task impairments can have critical real-world implications. For example, a wealth of research has demonstrated that driving performance is impaired by the addition of an engaging secondary task, such as talking on a hands-free cell phone (e.g., Strayer, Drews, & Johnston, 2003) or text messaging (Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009). Similarly, Neider, McCarley, Crowell, Kaczmarski, and Kramer (2010) found that when crossing an intersection, participants made fewer successful street crossings when talking on a hands-free phone than when crossing undistracted (see also Hatfield & Murphy, 2007; Nasar, Hecht, & Wener, 2008).

Though many people believe they are able to multitask effectively (e.g., Horrey, Lesch, & Garabet, 2009), Watson and Strayer (2010) suggested that only 2.5% of the population is able to multitask with little or no cost. This dissociation between actual and perceived multitasking ability is likely to blame for the general public's persistent engagement in what research has demonstrated to be clearly dangerous combinations of behaviors, such as texting while driving.

One demographic that might be a good candidate for elevated multitasking ability is experienced action video game players (AVGPs). Action video games refer to the class of games that include first-person shooters and racing games. Although the specific tasks in each game differ, these games share common perceptual and cognitive demands, including the need to rapidly divide attention, monitor multiple targets, and execute rapid responses. Recent research has found evidence of perceptual and attentional benefits related to action video game experience (but see Boot, Blakely, & Simons, 2011; Boot, Kramer, Simons, Fabiani, & Gratton, 2008). Compared to nongamers (NVGPs), AVGPs show heightened contrast sensitivity (Li, Polat, Makous, & Bavelier, 2009) and visual acuity (Green & Bavelier, 2007) and are more efficient at processing multisensory stimuli (Donohue, Woldorff, & Mitroff, 2010). AVGPs also outperform NVGPs when tracking moving objects (Green & Bavelier, 2006), localizing peripheral targets (Green & Bavelier, 2003), searching for rare targets (Fleck & Mitroff, 2008), and detecting changes in scenes (Clark, Fleck, & Mitroff, 2011). It is unknown whether such cognitive benefits result from playing action games or from self-selection, though some research suggests that training NVGPs on action video games can engender similar cognitive benefits (e.g., Green & Bavelier, 2003, 2006; but see Boot et al., 2008), and training on the Space Fortress game has shown transfer to real-world tasks (Gopher, Weil, & Bareket, 1994).

Although action video games require players to divide attention among multiple tasks and targets, it is unclear whether action video game experience is related to general improvements in multitasking performance. Although research suggests a gamer advantage on many single task measures of perception and attention, studies comparing the performance of AVGP and NVGP on divided attention tasks have thus far produced mixed results. In one study, Strobach, Frensch, and Schubert (2012) had AVGPs and NVGPs perform two computer-based tasks: a dual task paradigm where participants executed two tasks simultaneously and a task switching paradigm where participants alternated between two tasks. Compared to NVGPs, AVGPs had smaller divided attention costs when performing one versus two tasks in the dual task paradigm and also showed smaller decrements when switching between tasks on the task switching paradigm. Strobach and colleagues also found that 15 hr of action video game training produced similar benefits in a group of NVGPs. In another study, Donohue, James, Eslick, and Mitroff (2012) had AVGPs and NVGPs perform a multiple object tracking task, a paper and pencil search task, and a driving tracking task, with and without an auditory secondary task. Contrary to the action game benefit demonstrated by Strobach and colleagues, Donohue and colleagues found that AVGPs and NVGPs showed comparable dual task costs on each of the three tasks, suggesting that AVGPs were no more insulated than were NVGPs against the costs typically associated with dividing attention.

One critical difference between the studies is the nature of the tests. Strobach and colleagues (2012) used computer-based measures of divided attention where subjects made speeded responses. This context is, structurally, very similar to action video games. Conversely, Donohue and colleagues (2012) tested AVGPs and NVGPs on tasks that were less similar to the gaming environment (e.g., paper and pencil search). The degree of similarity between the action video game and divided attention task may mediate the extent to which AVGPs show an advantage over NVGPs. Some research has also failed to find benefits of action video game experience on single task cognitive measures (see Ackerman, Kanfer, & Calderwood, 2010; Boot et al., 2008; Boot et al., 2011; Owen et al., 2010), which suggests that AVGP benefits may be very sensitive to changes in the tasks.

Of great importance is the question of whether benefits associated with action video game experience extend to performance on safety-critical real-world tasks, such as driving or crossing the street. Unlike simpler and slower-paced games (e.g., Tetris), action video games share a number of characteristics with complex real-world tasks. For instance, players must divide attention and maintain simultaneous representations of multiple moving objects, and make fast-paced decisions. We might therefore expect that the skills necessary for playing action video games are also important for performing other complex tasks.

The goal of the present study was thus to examine the dual task performance of AVGPs and NVGPs in a complex real-world task, using a well-validated high-fidelity street crossing paradigm (Neider et al., 2010). The street crossing task was performed in an immersive virtual reality CAVE at the University of Illinois Simulator Lab (http://isl.uiuc.edu/Labs/CAVE/CAVE.html). To cross the street, participants walk on a manual treadmill, producing a high level of realism within a well-controlled task. A no distraction condition serves as a baseline to compare the effects of dual task manipulations (e.g., cell phone conversations, working memory tasks). Previous research has established the sensitivity of the street crossing task to group differences in divided attention performance, including age (Neider et al., 2011), frailty (Nagamatsu et al., 2011), sport experience (Chaddock, Neider, Voss, Gaspar, & Kramer, 2011), and fitness (Chaddock, Neider, Lutz, Hillman, & Kramer, 2012).

Compared to traditional laboratory tests of multitasking ability, the street crossing task is complex in terms of task requirements. Participants must attend to multiple moving vehicles, accurately perceive and extrapolate the velocity and relative position of these vehicles, and integrate these representations with judgments about their own walking speed to determine when it is safe to cross (Rosenbaum, 1975). The ability to manage multiple concurrent tasks and make speeded responses is also important to action video game play, and the goal of this study was to determine whether the skills associated with action video game experience produce real-world benefits. The street crossing task is also rich in performance measures (e.g., crossing accuracy, preparation time, head turns), which allows for greater characterization of performance in single and dual task conditions. These attributes make the street crossing paradigm ideal for studying group differences in dual task performance in a realistic context.

Here, we compared AVGPs and NVGPs in two conditions in the street crossing task: a crossing condition without distraction (single task) and a dual task condition where participants performed a continuous working memory task while crossing. If AVGPs are better than NVGPs at dividing attention in a complex task, as suggested by Strobach and colleagues (2012), then we would expect to find smaller dual task costs for AVGPs than for NVGPs. If, however, AVGPs and NVGPs were equally vulnerable to the costs of dividing attention, as suggested by Donohue and colleagues (2012), then we would expect AVGPs and NVGPs to show similar dual task impairments. An action gamer advantage on a real-world task would have important implications and might suggest that action video game training could improve the cognitive abilities needed for complex task performance. We also included a battery of computer-based cognitive tasks, including a dual task paradigm and measures of visual attention. We were thus able to test whether AVGP outperformed NVGP on computer-based measures of multitasking performance (similar to what has been done in previous studies) as well as a simulated real-world situation, street crossing.

METHOD

Participants

A total of 60 young adults (ages 18–29, M = 21.9, SD = 2.7) were recruited from the University of Illinois Urbana-Champaign. All participants had normal or corrected-to-normal vision (evaluated using a Snellen chart) and normal color vision (evaluated using Ishihara plates) and were paid $8 per hour for their participation. Prior to participating, potential participants completed a video game questionnaire, which was used to classify potential participants as AVGPs or NVGPs. Participants who played first-person shooter action video games (e.g., *Call of Duty, Unreal Tournament*) for at least 5 hr per week for the last 12 months were classified as AVGPs. Participants who played less than 1 hr per week over the last 12 months were classified as NVGPs (Green & Bavelier, 2006). Potential participants falling between these limits were excluded from the study. In all, 30 participants were classified as AVGPs and 30 participants were categorized as

TABLE 1: Demographic Information and Cognitive Battery Results

	AVGP (n = 30)		NVGP (n = 30)	
	M	*SD*	*M*	*SD*
Age (years)	22.3	2.5	21.5	2.5
# female	15	15		
AVG hours/week	7.7	1.4	0.1	0.3
Choice RT (ms)	425.4	51.2	424.9	60.4
Computer dual task				
Single task RT (ms)	883.2	240.4	1015.5	181.1
Dual task RT (ms)	1254.8	293.3	1442.4	226.2
FFOV percentage correct	58.2	19.8	50.1	25.1
Flanker task				
Congruent RT (ms)	412.3	65.7	411.8	70.6
Incongruent RT (ms)	470.8	68.4	466.1	70.6
VSTM percentage correct	79.6	6.7	78.0	7.0

Note. AVG = action video game; AVGP = action video game player; FFOV = function field of view; NVGP = non–video game player; RT = reaction time; VSTM = visual short-term memory.

NVGPs. Demographic information is presented in Table 1.

Street Crossing Paradigm

The street crossing task was performed in the virtual reality CAVE environment at the Beckman Institute Illinois Simulator Lab (Figure 1). The CAVE environment comprises three 303 cm × 273 cm screens and a floor. Screen resolution was 1,024 × 768 pixels. Participants stood approximately 150 cm from each of the screens, creating a visual angle of 91° × 85°. A custom program using a combination of C++ and Python controlled the experiment. An Ascension Flock of Birds 6DOF electromagnetic head tracker was used to measure head position and orientation. Head movements were classified as any movement traversing at least 10° in one direction to 10° in the other direction. Participants wore CrystalEyes liquid crystal shutter goggles throughout the experiment to create the impression of depth.

Figure 1. The street crossing simulator in the CAVE at the Beckman Institute Illinois Simulator Lab.

On each trial, participants were asked to cross a busy street at an unsigned intersection. The roadway comprised two 4-m-wide lanes, with cars traveling from both directions (i.e., from the participant's right and left). During half the trials, car speed was constant at 22.37 mph, creating consistent gap distances (of 75 m) between vehicles. For the other half, car speed ranged between 17.90 and 26.84 mph, creating inconsistent gap distances (which expanded or contracted based on the speed of the vehicle ahead and behind). Traffic density (i.e., the number of cars passing in front of the subject per unit time) was similar across the two speed conditions. To traverse the virtual intersection, participants walked on a manual treadmill that was synchronized to the CAVE environment. Participants were instructed to hold a handrail on the treadmill during the entire experiment, and an experimenter stood behind the participant to guard against falls.

Each trial began with the participant located on the sidewalk facing the simulated street. Participants were asked to cross the street as they normally would and were instructed to walk at whatever pace they saw fit, but were not allowed to run. After crossing, participants reached a gate, which began the next trial. Participants received visual and auditory feedback (i.e., the screen turned red and a screeching sound was heard) if they were struck by a car while crossing. Participants completed 96 street crossing trials and were allowed to rest between trials and blocks.

Two important modifications were made to the street crossing paradigm as used in previous studies (i.e., Nagamatsu et al., 2011; Neider et al., 2010; Neider et al., 2011). First, we replaced the simulated cell phone conversation with a working memory task, a *continuous auditory 2-back task*. Participants heard a number (1–9) every 3 s and reported, via buttons on the handrails, whether the number matched the number two items prior. This allowed us to objectively assess performance on the secondary task (something that would be difficult to do with a simulated conversation) and to examine performance costs as a function of divided attention (e.g., Becic et al., 2010). Prior to the street crossing task, participants completed a block of 2-back-only trials, which served as the single task baseline for 2-back accuracy. Second, participants were not constrained by any time requirement and were free to cross when they felt ready. The study was a 2 (single vs. dual task) × 2 (AVGP vs. NVGP) mixed design.

Cognitive Battery

Prior to completing the street crossing task, participants completed a five-task cognitive assessment. The order of the tasks was counterbalanced across subjects, and the entire battery took approximately 45 min to complete.

In the *choice response time* task, participants saw a fixation cross, followed by the letter A or B, and responded by pressing one of two corresponding keys. Participants completed 8 practice trials and 48 experimental trials.

In the *computer dual task* paradigm, participants performed two tasks, both separately and simultaneously. In one task, participants determined whether a letter was an A or B and pressed corresponding keys with their right hand. In the second task, participants determined whether a number was a 2 or 3 and pressed a corresponding key with their left hand. On single task trials (50%), participants performed only one task. On dual task trials (50%) they performed both tasks simultaneously. Participants completed 20 single task and dual task practice trials, followed by two blocks of 40 intermixed single and dual task test trials. This task is similar to the computer dual task assessment used by Strobach and colleagues (2012) and provides an index of the cost (to reaction time) of responding to two simple stimuli compared to responding to a single stimulus.

In the *functional field of view* (FFOV) task (similar to Green & Bavelier, 2003), participants searched for a white triangle within a circle among square distracters in a briefly (44 ms) presented display. Targets were presented with equal probability on one of eight radial spokes at eccentricities of 10°, 20°, and 30° from fixation. A 100 ms mask consisting of random black and white lines and shapes followed the search display. Participants then clicked with the mouse on the spoke where the target appeared. Participants completed 24 practice trials followed by 120 test trials. The FFOV measures the area in which an observer can process visual information without an eye movement.

In the *flanker* task (Eriksen & Eriksen, 1974), participants saw a line of 5 arrows at the center of the display (e.g., <<<<<). Participants responded to the direction of the center arrow by pressing a corresponding button on the keyboard. On congruent trials, the direction of the central arrow matched the direction of the flanking arrows. On incongruent trials, the direction of the central arrow was opposite that of the flanking arrows (e.g., <<><<), such that participants had to inhibit the surrounding arrows to respond accurately. Participants completed 40 practice trials followed by 100 test trials of randomly intermixed congruent and incongruent trials. The flanker task is an index of executive control, particularly inhibition of irrelevant information.

Finally, in the *visual short-term memory* (VSTM; Luck & Vogel, 1997) task, participants

TABLE 2: Street Crossing Results

	AVGP (n = 30)				NVGP (n = 30)			
	Single Task		Dual Task		Single Task		Dual Task	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Crossing percentage correct	94.2	5.3	90.4	5.2	91.5	7.6	88.4	12.7
Preparation time (s)	7.2	1.9	9.0	3.5	7.7	2.9	8.7	4.0
Crossing time (s)	5.1	0.8	5.3	1.0	5.4	0.8	5.7	1.1
Head turns	3.7	2.1	3.6	3.1	4.0	1.8	3.3	1.8
Time to contact (s)	5.8	0.4	5.7	0.5	5.9	0.4	5.7	0.3
2-back percentage correct	85.0	4.3	75.1	6.3	84.2	5.2	76.4	8.1

Note. AVGP = action video game player; NVGP = non-video game player.

saw four briefly presented (66.7 ms) colored shapes displayed simultaneously in a row across the center of the display. This screen was followed by a test display, where participants saw a probe shape and were asked whether the probe was part of the initial display. In 50% of the trials, the probe shape was part of the initial display. Participants responded "yes" or "no" by pressing corresponding keys. Participants completed 54 practice trials followed by 162 experimental trials. The VSTM task measures participants' ability to rapidly encode and recall visual information.

RESULTS

Street Crossing

Crossing performance was analyzed using an ANOVA with task condition (single vs. dual) as a within-subjects factor and action video game experience (AVGP vs. NVGP) as a between-subjects factor. The reported statistical values include conventional test statistics, p values, and the effect size measure η^2_p, along with $p_{BIC}(H_1|D)$, an estimate of the posterior probability of the alternative hypothesis given the observed data (Masson, 2011; Wagenmakers, 2007). Thus, a value of $p_{BIC}(H_1|D)$ less than .5 favors the null hypothesis and a value of greater than .5 favors the alternative. Crossing results are displayed in Table 2.

Crossing success. Crossing success was defined as the percentage of trials on which a participant successfully crossed the street (i.e., avoided a collision). As expected, participants were more successful in the single task condition (92.0%) than in the dual task condition (89.4%), $F(1, 58) = 14.05$, $p < .001$, $\eta^2_p = .195$. The main effect of video game group was not significant, $F(1, 58) = 1.45$, $p = .23$, $\eta^2_p = .024$, $p_{BIC}(H_1|D) = .21$, nor was the interaction between group and task condition, $F(1, 58) = 0.12$, $p = .74$, $\eta^2_p = .002$, $p_{BIC}(H_1|D) = .12$, indicating that AVGPs and NVGPs were equally successful when crossing (92.3% vs. 89.5%, respectively) and were similarly impaired by the secondary task. AVGPs showed a 3.8% drop in accuracy in the dual task condition, whereas NVGPs showed a 3.1% drop. An analysis of statistical power revealed that the probability of detecting a small, medium, and large effect size ($\eta^2 = .01, .06, .14$) for the Group × Session interaction was .42, .99, and .99, respectively.

Preparation time. Preparation time was defined as the duration when participants stood on the sidewalk next to the street prior to crossing. Longer preparation times are theorized to index increased difficulty making decisions about when it was safe to cross (Neider et al., 2011). As predicted, participants took significantly longer to initiate their crossing in the dual task condition (8.9 s) than in the single task condition (7.5 s), $F(1, 58) = 15.17$, $p < .001$, $\eta^2_p = .207$. More important, AVGPs and NVGPs showed no difference in preparation time (8.1 s vs. 8.2 s), $F(1, 58) = 0.02$, $p = .88$, $\eta^2_p = .001$, $p_{BIC}(H_1|D) = .12$, and both groups demonstrated similar costs in the dual task condition (1.8 s vs. 1 s), $F(1, 58) = 1.21$, $p = .28$,

η^2_p = .02, $p_{BIC}(H_1|D)$ = .19. This suggests that dividing attention had a similar impact on the decision making regardless of whether participants were AVGPs or not.

Head turns. The mean number of head turns during preparation (i.e., prior to crossing) was computed. Participants made significantly fewer head turns in the dual task condition (3.5) than in the single task condition (3.9), $F(1, 58) = 5.08$, $p = .028$, $\eta^2_p = .081$. AVGPs and NVGPs made a similar number of head turns (3.7), $F(1, 58) = 0.003$, $p = .96$, $\eta^2_p = .001$, $p_{BIC}(H_1|D) = .12$, and showed a comparable reduction in head turns in the dual task condition (0.1 vs. 0.7), $F(1, 58) = 2.52$, $p = .12$, $\eta^2_p = .042$, $p_{BIC}(H_1|D) = .32$.

Crossing time. Crossing time was defined as the time taken after leaving the sidewalk on the starting side of the street until arriving at the sidewalk on the opposite side of the street on successful trials. Participants were slower to cross in the dual task condition (5.5 s) than in the single task condition (5.3 s), $F(1, 58) = 39.07$, $p < .001$, $\eta^2_p = .402$. Again, there were no differences between AVGPs and NVGPs (5.2 s vs. 5.5 s), $F(1, 58) = 1.16$, $p = .29$, $\eta^2_p = .02$, $p_{BIC}(H_1|D) = .19$, and both groups experienced similar increases in crossing duration in the dual task condition (0.2 s and 0.3 s), $F(1, 58) = 0.06$, $p = .81$, $\eta^2_p = .001$, $p_{BIC}(H_1|D) = .12$.

Time to contact (TTC). TTC was calculated by dividing the distance from the nearest vehicle when the participant entered the roadway by the speed of that vehicle. This provides an index of how risky a particular crossing decision is. Smaller TTC indicates that a participant came closer to colliding with a vehicle when the crossing was initiated, and thus indexes less safe behavior. TTC did not change as a function of task load, $F(1, 58) = 1.13$, $p = .29$, $\eta^2_p = .019$, $p_{BIC}(H_1|D) = .19$. Most important, there was no difference between AVGPs (5.8) and NVGPs (5.8 s), $F(1, 58) = 0.82$, $p = .37$, $\eta^2_p = .014$, $p_{BIC}(H_1|D) = .16$, and TTC did not change differentially as a function of load across groups, $F(1, 58) = 0.04$, $p = .85$, $\eta^2_p = .001$, $p_{BIC}(H_1|D) = .12$, suggesting that both AVGPs and NVGPs made similar crossing decisions in both the single and dual task conditions.

Secondary task performance. Secondary task performance was defined by accuracy on the auditory 2-back working memory task. For this analysis, the single task condition refers to performance during the 2-back-only blocks. As expected, participants were considerably less accurate in the dual task condition (75.8%) than the single task condition (84.6%), $F(1, 58) = 180.34$, $p < .001$, $\eta^2_p = .757$, suggesting that dividing attention also impaired performance on the memory task. Critically, AVGPs and NVGPs showed similar working memory performance (80.1% vs. 80.3%), $F(1, 58) = 0.27$, $p = .61$, $\eta^2_p = .005$, $p_{BIC}(H_1|D) = .13$, and both groups demonstrated similar performance costs when dividing attention between the 2-back and crossing tasks (9.9% vs. 7.8%), $F(1, 58) = 0.75$, $p = .39$, $\eta^2_p = .013$, $p_{BIC}(H_1|D) = .32$.

Cognitive Battery

Data from the cognitive battery are presented in Table 1. AVGPs and NVGPs had similar reaction times on the choice reaction time task, $t(1,58) = 0.037$, $p = .97$. On the computer dual task paradigm, reaction times were entered into an ANOVA with video game group (AVGP vs. NVGP) as a between-subjects factor and task condition (single vs. dual) as a within-subjects factor. Both groups were significantly slower in the single task condition than in the dual task condition, $F(1, 58) = 348.27$, $p < .001$, $\eta^2_p = .857$. AVGPs responded faster overall than did NVGPs, $F(1, 58) = 7.61$, $p = .008$, $\eta^2_p = .116$. However, both groups showed significant and similar reaction time costs in the dual task condition, $F(1, 58) = 1.73$, $p = .19$, $\eta^2_p = .029$, $p_{BIC}(H_1|D) = .24$. On the FFOV task, AVGPs and NVGPs were equally accurate in localizing peripheral targets, $t(1,58) = -1.40$, $p = .17$. On the flanker task, interference cost was calculated by subtracting mean reaction time on the congruent trials from mean reaction time on the incongruent trials. AVGPs and NVGPs showed similar costs to reaction time associated with interference in the incongruent condition, $t(1,58) = 0.67$, $p = .51$. Finally, on the VSTM task, identification accuracy was the primary measure; AVGPs and NVGPs were similarly accurate, $t(1,58) = 0.93$, $p = .36$. Overall, AVGPs and NVGPs demonstrated comparable performance on each of the cognitive assessments.

DISCUSSION

The goal of the present study was to compare the performance of AVGPs and NVGPs on a real-world divided attention task. Participants completed a high-fidelity street crossing task, with and without a cognitively challenging working memory task. Overall, we found no evidence of an action game-related advantage in street crossing performance. AVGPs and NVGPs were equally successful in crossing the street and showed similar decision making behavior. Most important, both groups showed significant, and equivalent, costs to crossing performance in the dual task condition. Both groups also demonstrated significant increases in preparation time and decreases in head turns in the dual task condition, suggesting that both AVGPs and NVGPs had increased difficulty deciding when it was safe to cross in the dual task condition. We also found significant dual task costs to secondary task performance, which corroborates previous research demonstrating that secondary task performance is impaired when attention is divided (e.g., Becic et al., 2010). Of importance, AVGPs and NVGPs also showed significant and similar dual task costs to working memory performance, and on a computer-based measure of dual task performance.

The literature on the relationship between action video game experience and dual task performance is equivocal. In addition, and most important, little is known about whether action video game experience translates to benefits on complex real-world tasks. This study provides the most rigorous examination of action video game experience and real-world task performance to date, and found no evidence for an AVGP advantage. These data suggest that action video game experience may not lead to improved performance in complex real-world tasks.

The street crossing simulator has been validated as a sensitive measure of group differences in multitasking performance in a real-world task in a number of other studies (Chaddock et al., 2012; Nagamatsu et al., 2011; Neider et al., 2010; Neider et al., 2011). The sample size in the present study was large compared to those of previous studies using the same paradigm, and examination of the Bayesian posterior probabilities lends support to the conclusion that the data better adhere to the null hypothesis.

These results differ from those of Strobach and colleagues (2012), who found that AVGPs showed smaller dual task and task switching costs than did NVGPs. One explanation for the discrepancy in these findings is the nature of the divided attention tasks. Strobach and colleagues (2012) had participants make speeded responses to stimuli presented on a computer. These tasks are much more similar to action video games, in terms of both the stimuli and the required responses, and thus action video game experience may have transferred well to these tasks. In the present study however, we failed to replicate this AVGP advantage in computer-based dual task performance, though AVGPs were significantly faster overall than were NVGPs.

The present study and the study by Donohue and colleagues (2012) employed paradigms less similar to the action video game environment, and each failed to find an advantage for AVGPs over NVGPs in divided attention performance. For instance, Donohue and colleagues found that AVGPs and NVGPs showed comparable costs to performance on a driving tracking task when participants were cognitively distracted by a secondary task. Thus, it may be the case that perceptual and attentional benefits associated with action game play may not transfer to complex, real-world tasks; our results suggest caution when extrapolating such results to the real world.

We also failed to find differences between AVGP and NVGP on other computer-based cognitive tests, which contradicts previous findings in the video game literature (e.g., Green & Bavelier, 2003). These results highlight the inconsistency in the video game and cognition literature and suggest that small procedural and stimulus changes may reduce or eliminate the benefit of action video game experience. This provides further evidence that video game experience is unlikely to translate to performance on complex real-world tasks.

An interesting deviation from street crossing studies (i.e., Neider et al., 2010; Neider et al., 2011) is the finding that crossing times increased in the dual task condition. Previous studies that used this street crossing paradigm showed comparable crossing times in both the single task and dual task condition. The "walking while talking" literature, however, suggests that increases in cognitive load negatively affect balance and gait (e.g., Lindenberger, Marsiske, &

Baltes, 2000). In the present study, increased crossing duration during the dual task condition may have resulted from changing the secondary task from a naturalistic conversation to a working memory task. When conversing, participants may have restricted their conversations. However, in the present study, they were unable to pause the working memory task while walking, which may have resulted in increased dual task impairment.

The impact of dividing attention in complex tasks is serious (e.g., Strayer et al., 2003), and only a small percentage of the population can be classified as "supertaskers" (Watson & Strayer, 2010). The impact of video game experience and training on perception and attention is under dispute (see Boot et al., 2011). Though the video game literature evidences cognitive and attentional benefits associated with action video game play, the present results failed to find an AVGP advantage over NVGPs on a rigorous test of real-world multitasking ability, suggesting that action video game training will not improve performance on at least some important real-world tasks, although future research should examine the relationship between action video game experience and other real-world tasks such as driving.

KEY POINTS

- Action video game experience is associated with advantages on single task measures of perception and cognition, but it is unclear whether experienced action video game players actually outperform nongamers on divided attention tasks.
- We tested dual task performance in a high-fidelity street crossing task, with and without cognitive distraction.
- Action gamers and nongamers performed similarly during street crossing, and both groups showed significant costs to crossing performance in the dual task condition.
- Perceptual and attentional benefits associated with action video game experience do not translate to complex street crossing performance that entails multitasking.

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John G. Gaspar is a PhD student in the Department of Psychology and Beckman Institute at the University of Illinois Urbana-Champaign. He earned his MA in psychology from the University of Illinois in 2012.

Mark B. Neider is an assistant professor in the Department of Psychology at the University of Central Florida. He earned his PhD in cognitive/experimental psychology from Stony Brook University in 2006.

James A. Crowell is a visualization programmer at the Illinois Simulator in the Beckman Institute at the University of Illinois. He earned his PhD in cognitive psychology from the University of California, Berkeley in 1993.

Aubrey Lutz is a lab manager at the Lifelong Brain and Cognition Lab in the Beckman Institute at the University of Illinois. She earned her BS in psychology from the University of Illinois in 2008.

Henry Kaczmarski is the director of the Illinois Simulator Lab in the Beckman Institute at the University of Illinois. He earned his BSEE in electrical engineering from the Illinois Institute of Technology in 1972.

Arthur F. Kramer is the director of the Beckman Institute for Advanced Science and Technology and the Swanlund chair in neuroscience and psychology at the University of Illinois. He earned his PhD in cognitive/experimental psychology from the University of Illinois in 1984.

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