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Driving is not a game: Video game experience is associated with risk-taking behaviours in the driving simulator

Arne Stinchcombe [a, b, *], Yara Kadulina [a], Chantal Lemieux [a], Rumaisa Aljied [a], Sylvain Gagnon [a]

[a] School of Psychology, University of Ottawa, Canada
[b] Centre for Research on Safe Driving, Lakehead University, Canada

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ABSTRACT

The purpose of the present investigation was to assess the impact of self-reported video games experience on performance in the driving simulator. Two simulator experiments were executed using convenience samples of young drivers who completed a simulated drive and a questionnaire that quantified their experience playing video games. In the first experiment, participants completed a comprehensive simulated driving assessment where composite indicators of overall driving performance were collected. In the second experiment, participants completed a simulated driving scenario specifically designed to assess drivers' handling abilities. The results showed a statistically significant association between video game experience and measures of speed and crash only in the handling scenario that participants completed in the second experiment. The results suggest that video game experience contributes to simulated driving behaviour through its relationship with risk taking behaviours among young drivers.

With advances in computing technology, driving simulators have emerged as an affordable and safe tool for research, training, and assessment of drivers. Driving simulators present drivers with an interactive and realistic virtual visual and auditory environment equipped with vehicle controls (i.e., steering wheel and pedals) that emulate a real-world vehicle. Research has shown that driving performance in the driving simulator is highly similar across various simulation platforms and is associated with driving performance on the open road (Bédard, Parkkari, Weaver, Riendeau, & Dahlquist, 2010; Lemieux, Stinchcombe, Gagnon, & Bédard, 2014).

The use of the driving simulator assumes that the driving simulator is a proxy for real-world driving and that the resulting behavioural data is a reflection of driving ability. Simulators have been used to examine research questions that involve cross sectional comparisons of older and younger drivers' performance (e.g., Stinchcombe, Gagnon, Zhang, Montembeault, & Bédard, 2011), correlations between cognitive measures and drivers' performance (Yamin, Stinchcombe, & Gagnon, 2016), examination of driving responses under conditions that either ameliorate or decrease the ability to driver (Joanisse, Gagnon, & Voloaca, 2012). Regardless of their application, there is an expectation that driving simulators elicit behaviours that correspond with what would be expected on the real road, a concept often referred to as behavioural validity (Mullen, Charlton, Devlin, & Bédard, 2011). However, for many participants, driving simulators are a novel apparatus and authors have suggested that, among some clinical populations, this novelty may hinder they performance in the driving simulator (Lundberg & Hakamies-Blomqvist, 2003). For this reason, driving simulator testing protocols often include an acclimation phase that involves having participants drive through a scenario of increasing complexity so that they may become sufficiently familiar with the simulator.

On the other hand, some participants may already have extensive experience in a driving simulator or similar platforms, making them more comfortable and allowing them to achieve a level of performance in the simulator that exceeds their driving ability in a real-world vehicle or allowing them to exceed the ability of other participants taking part to the same experiment. For instance, current racing style video games also mimic driving, albeit for strictly entertainment purposes. Like driving simulators, these games present players with audio, visual, and in some cases, tactile cues. Video games differ from driving simulators in that they often

* Corresponding author. 136 Jean-Jacques Lussier, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada.
E-mail address: astinchc@uottawa.ca (A. Stinchcombe).

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reward speeding and colliding with one or more vehicles. Indeed, performance in these video games emphasizes engaging in highly technical maneuvers at high speeds as opposed to safety which is emphasized in the driving simulator. Research suggests that video game play is a common activity among adolescents. Cummings and Vandewater (2007), for example, showed that 36% of adolescents in the United States play video games regularly. Other data indicate that racing video games represented 4.6% of the most popular video games in the United States in 2013 (ESA., 2014).

The relationship between video game experience and driving behaviour has been documented in the literature (e.g., Rupp, McConnell, & Smither, 2015) and has been suggested to relate with both cognitive/perceptual skills and to the emotional processes that regulate sensation seeking (Ciceri & Ruscio, 2014). Indeed, there are numerous similar perceptual and cognitive processes at play in the driving simulator and in video games which are likely to be enhanced by repeated exposure (i.e., practice). In particular, experience with video games has been shown to improve perception, motor-skills, attention, cognitive control, and speed of processing (Achtman, Green, & Bavelier, 2008; Dye, Green, & Bavelier, 2009; Green & Bavelier, 2003, 2007), all of which are critical for safe driving. Rupp et al. (2015), for example, examined the relationship between action video game experience and performance in a distracted driving task. Their results indicated that experienced gamers showed fewer lane deviations in comparison to non-gamer controls. When drivers were presented with a distraction task, however, no statistically significant differences in lane deviation were observed.

Video games have been also been shown to have negative effects such as increasing positive attitudes towards violence, and risk taking behaviours, particularly among adolescents (Anderson & Bushman, 2001). For example, using questionnaires, Beullens, Roe, and Van den Bulck (2011) showed that video game playing during adolescence was related to later risky driving behaviour. These authors suggest that the relationship may, in part, be explained by the video games' content. In a series of three related experiments examining experience playing racing games and driving, Fischer, Kubitzki, Guter, and Frey (2007) showed that the frequency of playing racing games was positively associated with competitive driving, obtrusive driving, and car accidents. Through experimental manipulation they also demonstrated that, in comparison to playing a neutral video game, playing a racing style game led to changes in cognitions and affect that are positively associated with risk taking.

Given the above-cited evidence, it is reasonable to hypothesize that video game experience may contribute to some of the variance in simulator driving performance, especially among younger adults who represent the largest group of video game users. Within research studies, a strong effect of video game experience on simulator performance could undermine the behavioural validity of a driving simulator used in a particular study and confound the results. Similarly, this effect may offer an advantage to experienced gamers in the simulator, a difference that may not be reflective of real-world driving. To test this prediction we examined the association between video game experience and simulated driving performance among younger drivers in the context of two driving simulator experiments.

1. Experiment 1

The purpose of Experiment 1 was to examine the role of video game experience and performance in a driving simulator as assessed by a standardized assessment course. It was hypothesized that participants' performance would be positively related to their self-reported experience playing racing video games, such that performance in the simulator would increase alongside video game experience. Data for this analysis were collected as part of a broader investigation that examined the reliability of driving performance across simulated platforms, described in detail in Lemieux et al. (2014).

1.1. Method

1.1.1. Participants

A convenience sample of 52 young adults (24 males, 28 females), with an average age of 19.25 years (SD = 2.17) participated in the first experiment. All participants were enrolled in a psychology course at the University of Ottawa and received course credit for participation. All participants reported having a valid driver's license for at least one year. Prior to participation, participants completed an informed consent form. The study was approved by the Office of Research Ethics and Integrity at the University of Ottawa.

1.1.2. Video game experience

To examine video game experience, we developed a brief questionnaire with seven questions asking each participant to identify the average number of hours per week that they played video games at specific ages. The items that were included in the questionnaire and descriptive statistics are presented in Table 1.

1.1.3. Driving simulator task

All participants completed two identical simulated driving assessments: one in a mid-level driving simulator and another in a single-screen low-level driving simulator. The mid-level driving simulator consisted of the Systems Technology Inc. interactive driving simulator (STISIM). Sitting in a fixed-base car seat, the participant had a 135° horizontal field-of-view and a 75° vertical field of view, which was created by using three projectors placed above and behind the participant. The simulator projected the scene onto three screens measuring 75 cm × 90 cm each displayed at a rate of 30 frames per second (30 Hz). The low-level driving simulator consisted of a single PC equipped with a 19-inch LCD color monitor, two computer speakers, a Logitech steering wheel and brake/throttle, and a standard stationary office chair. In the LLS, participants had a 60° horizontal field of view and a 75° vertical field of view. The frame rate of the LLS was also 30 frames per second (30 Hz).

The simulated driving assessment course was programmed to mimic a driving assessment by a provincial regulatory body in Canada and is described in detail in Bédard et al. (2010) (see also Lemieux et al., 2014). The driving simulator collects a number of indices of driving performance such as variables related to lateral control, longitudinal control, and crashes. To generate a composite score of overall performance, errors collected by the simulator are summed (i.e., Simulator Errors). In addition, a rater scored each of the drives using a demerit point-based assessment, referred to as the rater score.

Our previous work showed that performance on the two simulators was statistically equivalent and, thus, for the purpose of the present analysis, performance across platforms was averaged for each participant.

1.2. Results

1.2.1. Correlations

To determine the association between video game experience and performance in the driving simulator, Pearson product moment correlation coefficients were computed between each of the items in the video game experience questionnaire and the

Table 1
Questions used to assess video game experience in Experiment 1.

Item	Mean	Standard deviation
Q1- Between the ages of 7 and 12, how many hours per week on average did you play computer and/or video games?	7.22	7.85
Q2 - Of the hours indicated in the previous question, how many of these hours on average were spent playing first-person racing games (e.g., Need for Speed, Gran Turismo, Forza Motorsport, NASCAR Racing, F1 Challenge, Midnight Club, etc.)?	1.73	3.98
Q3 - Between the ages of 13 and 18, how many hours per week on average did you play computer and/or video games?	6.56	9.90
Q4 - Of the hours indicated in the previous question, how many of these hours on average were spent playing first-person racing games (e.g., Need for Speed, Gran Turismo, Forza Motorsport, NASCAR Racing, F1 Challenge, Midnight Club, etc.)?	1.62	3.11
Q5 - Since (and including) the age of 19, how many hours per week on average did you play computer and/or video games?	6.76	13.08
Q6 - Of the hours indicated in the previous question, how many of these hours on average were spent playing first-person racing games (e.g., Need for Speed, Gran Turismo, Forza Motorsport, NASCAR Racing, F1 Challenge, Midnight Club, etc)?	1.80	4.73

driving outcomes. The results are presented in Table 2. Results showed no statistically significant relationships between video game experience and driving outcomes.

1.2.2. Tests of equivalence

To explore whether simulated driving performance differed between experienced video gamers and non-gamers, participants were grouped based on whether they played one or more hours of video games per week (i.e., experienced gamers) or whether they played less than 1 h of video gamer per week (i.e., non-gamers) since the age of 19 years. Of the total sample, 12 participants were classified as active gamers.

The results showed no statistically significant differences in driving performance between experienced gamers and non-gamers. In particular there were no statistically significant differences in terms of simulator errors ($F(1,50) = 0.021$, $p = 0.884$), rater score ($F(1, 50) = 0.013$, $p = 0.911$), and crash ($F(1, 50) = 0.213$, $p = 0.646$).

2. Experiment 2

The results of Experiment 1 revealed no statistically significant association between video games and driving using a comprehensive driving assessment with composite measures indicative of overall performance. The lack of observed relationship may be attributed to the fact that the scenario broadly assessed all aspects of behaviour necessary for safe driving and the composite measures used in the analysis reflect a sum of these behaviours. Our previous work demonstrated that vehicle handling is a prime skill that contributes to driving safety (e.g., Stinchcombe & Gagnon, 2010, 2013). It is reasonable to suspect that experience playing video games may exert its effect on specific driving skills, such as handling. If this were the case, a simulated driving scenario specifically designed to assess handling skills would be necessary to identify this relationship.

As a follow-up to Experiment 1, we sought to examine the relationship between driving behaviour and video game experience through a scenario designed to assess vehicle handling. Data for this analysis were collected as part of a broader investigation that examined the impact of stereotypes on objective measures of driving performance. The scenario used for this experiment required participants negotiate an urban area with road construction. Rather than assessing video game experience by asking participants to estimate time spent playing (i.e., continuous variables) and subsequently dividing the sample (i.e., gamers vs. non-gamers) based on an arbitrary criterion, as was the case in the first experiment, a new questionnaire was developed for the second experiment that had participants respond to items on a likert scale.

Table 2
Pearson correlation coefficients indicating relationship between video game experience and simulated driving outcomes.

Item	Errors in the simulator r (p)	Rater score r (p)	Number of crashes r (p)
Q1	0.038 (0.789)	0.143 (0.310)	0.034 (0.808)
Q2	0.021 (0.883)	0.084 (0.553)	0.152 (0.281)
Q3	0.049 (0.731)	0.012 (0.930)	0.012 (0.930)
Q4	0.029 (0.841)	0.083 (0.557)	0.065 (0.648)
Q5	0.293 (0.185)	0.070 (0.756)	0.085 (0.708)
Q6	0.187 (0.405)	0.214 (0.340)	0.300 (0.175)

2.1. Method

2.1.1. Participants

A total of 39 young drivers (18 males and 21 females) between the ages of 18–24 were recruited for this experiment. Participants were enrolled in an introductory Psychology course at the University of Ottawa and received course credit for their participation. All participants were required to hold a valid driver's license for at least one year to participate. All participants gave their informed consent and the experiment received REB approval at the University of Ottawa.

2.1.2. Video game experience

All participants completed a 5-item questionnaire where they indicated the extent of their experience playing video games. The

Table 3
Questions and associated response options used to assess video game experience in Experiment 2.

Item	Response options	Mean	Standard deviation
Q1 - Have you ever played video games?	1- Never 2 3- Occasionally 4 5 - Always	2.82	0.93
Q2 - For how many years have you been playing video games?	Open	8.49	7.06
Q3 - In general, how often do you currently play video games?	1 - Never 2 - 3- 4 - A few times a month 5 - 6 - 7 - Almost every day	2.95	1.87
Q4 - How often do you play 'drive em' up' style racing games such as Grand Theft Auto, Burnout, Need for Speed, etc?	1 - Never 2 - 3- 4 - A few times a month 5 - 6 - 7 - Almost every day	1.8	1.26
Q5 - How often do you play realistic style racing games such as Gran Turismo, Forza, Motorsports, etc.?	1 - Never 2 - 3- 4 - A few times a month 5 - 6 - 7 - Almost every day	1.45	0.93

Fig. 1. Screen capture from the construction scenario used in Experiment 2 that assessed drivers' handling skills.

Table 4
Descriptive statistics of driving outcomes in Experiment 2.

Variable classification	Variable	Mean	SD
Vehicle handling	Number of cones hit	3.74	3.29
	Off road accidents	0.03	0.16
	Out of lane (% time)	5.36	1.66
	Out of lane (% distance)	4.32	1.37
	Total number of centerline crossings	1.36	1.08
Speed	Number of speed exceedances	1.33	1.24
	Over the speed limit (% time)	1.31	1.56
	Over the speed Limit (% distance)	3.51	3.99

questionnaire items and descriptive statistics are presented in Table 3.

2.1.3. Driving simulator task

Participants completed an orientation scenario followed by several simulated driving scenarios in a driving simulator (i.e., STISIM, version 2.0). For experiment 2, participants drove on the mid-level driving simulator described in experiment 1. The simulated driving scenarios assessed specific skills and this analysis focused on variables obtained in a construction scenario that was 5 km in length and assessed vehicle handling by having participants negotiate traffic cones (see Fig. 1). Dependent variables of interest in this scenario included number of traffic cones hit, crash, and measures of speed and lateral control (see Table 4 for descriptive statistics).

2.2. Results

2.2.1. Correlations

Pairwise Pearson correlations were calculated between measures of driving performance in the driving simulator and items on the questionnaire of video game experience. The results indicated statistically significant correlations between videogame experience and driving speed and number of crashes (see Table 5). In particular, there was a strong and positive correlation between playing video games (i.e., Q1) and the proportion of time spent driving over the speed limit ($r = 0.416$, $p = 0.008$), the number of errors resulting from exceeding the speed limit ($r = 0.499$, $p = 0.001$), and the number of collisions ($r = 0.379$, $p = 0.017$). A similar pattern of results emerged when examining participants' current frequency of video game play (i.e., Q3) where more frequent game play was associated with the occurrence of collisions ($r = 0.351$, $p = 0.028$), errors resulting from speed exceedances ($r = 0.330$, $p = 040$) and the proportion of the distance spent driving over the speed limit ($r = 0.332$, $p = 0.039$). Finally, participants' self-reported frequency of fantasy racing game play (i.e., Q4) was positively related to the occurrence of crash in the driving simulator ($r = 0.354$, $p = 0.027$).

3. Discussion

An appreciable proportion of youth and young adults play video games and existing research suggests an influence of playing video games on driving. The purpose of the present investigation was to assess the impact of self-reported video game experience on performance in the driving simulator. Two simulator experiments were executed using convenience samples of young drivers with the goal of exploring this relationship.

The first experiment examined simulated driving performance of younger drivers through a scenario that was patterned after a real-world assessment course used for the issuance of drivers' licenses. The driving-related dependent variables examined were overall indicators of performance. All participants were asked about their experience playing video games during childhood as well as at the time that the experiment took place. The results showed no associations between video game experience and simulator driving performance. Similarly, when participants were grouped according to their video game experience (i.e., non-active gamers vs. active gamers), the results showed no statistically significant differences between groups. These results were counter to our initial hypothesis and we speculated that the lack of relationship between video game experience and simulated driving might have been attributed to the broad nature of the assessment

Table 5
Correlation matrix between items of video game experience questionnaire and driving outcomes in Experiment 2.

Item	Driving outcomes								
	Number of cones hit	Off road accidents	Total number of speed exceedances	Total number of centerline crossings	Total number of road edge excursions	Over speed limit (% Time)	Over speed limit % distance)	Out of lane (%time)	Out of lane (% distance)
Q1 - Ever played video games	0.047 (0.777)	0.379 (0.017)[a]	0.499 (0.001)[a]	0.263 (0.105)	−0.287 (0.077)	0.340 (0.034)[a]	0.416 (0.008)[a]	0.046 (0.782)	0.086 (0.604)
Q2 - Number of years have been playing video games	0.292 (0.071)	0.107 (0.515)	0.260 (0.110)	0.175 (0.288)	−0.089 (0.592)	0.170 (0.302)	0.204 (0.214)	−0.025 (0.880)	0.000 (0.999)
Q3 - General frequency of current video game play	−0.082 (0.621)	0.351 (0.028)[a]	0.330 (0.040)[a]	0.094 (0.567)	−0.153 (0.353)	0.299 (0.065)	0.332 (0.039)[a]	−0.007 (0.965)	0.101 (0.539)
Q4 – Frequency of fantasy racing game play	−0.187 (0.254)	−0.106 (0.522)	0.354 (0.027)[a]	0.067 (0.687)	−0.084 (0.613)	0.187 (0.255)	0.240 (0.141)	0.021 (0.899)	−0.084 (0.612)
Q5 - Frequency of realistic game play	−0.114 (0.491)	−0.081 (0.626)	0.270 (0.097)	0.014 (0.933)	−0.101 (0.541)	0.201 (0.220)	0.205 (0.210)	−0.086 (0.602)	−0.004 (0.982)

[a] Level of statistical significance $p < .05$.

scenario that was administered and the resulting composite indicators of driving behaviour.

In the second experiment a separate sample of young drivers completed a simulated driving scenario specifically developed to assess handling behaviors by presenting drivers with road construction through which they had to maneuver. This scenario was selected because it was shorter in length and assessed a specific set of skills, allowing for the examination of specific driving parameters such as measures of speed and lateral control. The findings indicated an association between video game experience and measures of speed and collision. In particular, as video game experience increased so did the occurrence of crash and speed exceedances in the simulator. The results from the second experiment suggested that video game experience was associated with poorer performance in the driving simulator rather than improved performance, as had originally been predicted.

Other researchers have observed a relationship between experience playing racing video games and risk taking behaviours while driving, a phenomenon that has been coined the racing-game effect (Fischer et al., 2009, 2007). Based on our findings, however, the effect only appears under certain circumstances. In particular, when examining the differing results between the two experiments, it is likely that the construction scenario used in Experiment 2 prompted the skills and attitudes that gamers have developed through years of video game play. The scenario involves navigating the traffic cones in a construction zone and it prompts the ability to drive in a driving context where obstacles are in the driver's path. In that regard, the scenario used in the second experiment differs significantly from that used in the first experiment. Therefore, the risk taking behaviors that we noted in the second experiment may be attributed to the content of the scenario; scenarios with content that approximates driving video games may trigger risk-taking behaviors among experienced video gamers. Interestingly, in a more neutral context such as a standardized assessment scenario, this type of behaviour did not appear among more frequent gamers. Most importantly, the skills developed as a result of the gaming experience did not improve the driving performance in the simulator.

Taken together, the results from these experiments show the influence of video game experience on simulator driving performance. Instead of improving simulated driving performance through improved cognitive and perceptual skills, the effect of video games appears to be related to risk taking behaviors which results in poor performance in the simulator. We observed an effect of video game experience only when handling behaviours were emphasized within the scenario, as was the case in the second experiment. These data offer a number of implications for driving researchers and professionals alike. Specifically, when designing studies that use driving simulators, researchers should consider the potential role video game experience may have on their results. Prior to executing a driving simulator experiment, it is worthwhile to examine the nature of the research question and hypothesis as well as to evaluate whether the findings may be confounded by inclusion of active video game players in the sample. In the event that the researcher determines that participants' video game experience is a potential threat to the behavioural validity of the driving simulator, appropriate steps may be taken to mitigate the effect. In the case of cross-sectional age-based comparisons, for example, researchers may consider excluding experienced video gamers from participating in the experiment. Depending on the recruitment strategy, this is unlikely to represent an appreciable number of individuals who will be excluded from participating based on this criterion. In our sample of young drivers enrolled in undergraduate studies, only approximately 10% of the sample reported actively playing video games on a daily basis. Alternatively, researchers could statistically control for video game experience if they have a sample where expert gamers are over-represented.

The obtained findings offer several insights into the relationship between video game experience and simulator driving performance. This investigation, however, is not without its limitations. In particular, the sampling frame for both studies recruited exclusively undergraduate students with a valid driver's license. While it is likely that young adults represent the most active group of video game users, it would be of interest to expand the sampling frame to gamers of other age groups. Similarly, the two studies described here were executed several years apart, which precluded having the same participants complete both experiments. Thus, we cannot ignore the possibility that differences in sample characteristics between Experiment 1 and 2 may have played a role in our findings. On the other hand, having separate participants in each experiment can be viewed as a strength given that repeated simulations may lead to practice effects. A related strength is that the samples were drawn from the same population of undergraduate students enrolled in Psychology.

The two studies presented here had participants complete questionnaires that were developed by the authors to assess experience with video games. While the brief questionnaires assessed video game experience, there were some differences in terms of the content of the individual items. Specifically, the questionnaire used in the first experiment had participants estimate their current and past experience playing video games in terms of the number of hours of video game play. In contrast, the questionnaire used in the second experiment had participants rate current experience with video games using a likert scale. Thus the difference in findings between the two studies may also be attributed to the differences in the content of the questionnaires used. Both questionnaires exhibited high face validity and, as a follow-up, it would be of value to examine which questionnaire is most related to objective measures of video game experience such as performance while playing racing video games. Determination of the most appropriate measure of video game experience would aid researchers to statistically control for video game experience and help professionals identify expert video gamers.

The present investigation found a statistically significant association between video game experience and risk taking behaviors (i.e., measures of speed and crashes) in the driving simulator, only when participants were presented with a simulated driving scenario designed to assess a specific driving related skill (i.e., handling). Within the context of driver training and assessment using a driving simulator, road safety professionals should inquire about whether the driver has extensive experience using video games. In the event that participants report extensive experience, professionals could make efforts to reduce the occurrence of risk-taking behaviours. Instead of rewarding risk-taking behaviour as is the case within racing style video games, driving professionals could reinforce safe driving behaviours in the simulator through the provision of feedback.

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