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Effects of Regular and Irregular Video Game Experience on High-Risk Driving Behaviour

by

Aimée Michelle Pearson

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Effects of Regular and Irregular Video Game Experience on High-Risk Driving Behaviour

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Introduction

The effect of violent video games on driving behaviour is an increasingly popular subject of investigation. Violent media has generally referred to any media that depicts the intentional infliction of harm towards a person or even a fictional character (Anderson & Bushman, 2001).Violent television and cinema media that depict acts such as fighting and gun violence have been blamed for aggressive and high-risk behaviours. Whether violent media influences behaviour has also been a source of debate both in popular media and research investigations. The rapid growth of the video game industry since the 1980's has also brought concerns and criticisms, particularly to the violent and deviant themes presented in video games (Zhang, Yang & Li, 2010). Generally, video game research on social behavior has focused on the negative influences of this exposure including aggression and risk-taking(Carnagey, Anderson & Bartholow, 2007; Fischer, Kubitzki, Gutener & Frey, 2007; Bartlett, Vowels, Shanteau, Crow & Miller, 2009; Fischer, et al., 2009; Hardigree, 2011).

Unlike television/cinema media, video games require players to actively engage in simulated violent and deviant behaviours such as attacking, shooting, stealing and reckless driving within the game context. First-person shooter video games, where players are actively shooting and killing others, have been subject to a great deal of criticism for instigating violent behaviours. A meta-analysis (Anderson & Bushman, 2001) indicated that violent video games increase physiological arousal, aggressive thoughts and feelings, and decreased pro-social ('helping') behavior. Aggression, according to Anderson and Bushman (2001), is intentional harm towards another individual, but not accidents that result in harm. When considering the driving

environment, this distinction is important to make because drivers may choose to drive in a particular way that might be described as ‘aggressive’, but lack the intention to cause harm to others. It may be more appropriate to describe this behaviour as ‘high-risk’ rather than ‘aggressive’. However, video games are thought to have at least temporary implications for driving behavior.

Racing video games are a popular genre of video games on the market and tend to include violent and deviant themes. Many racing games (e.g. the *Need for Speed* and *Grand Theft Auto* franchises) promote and reward high-risk, harmful and aggressive on-road driving behaviour (Fischer et al., 2009). Specifically, some racing titles promote traffic violations, street racing, auto-theft, speeding, resisting police arrest and collisions. “Grand Theft Auto” is a racing game that has been blamed for several traffic incidents and has been under scrutiny as well as a sensationalist topic for news media (Hardigree, 2011). Continental Tyres (a German auto and truck parts manufacturing company) conducted a survey that collected self-report data from 2000 motorists regarding their driving habits and reported that motorists that played racing such as “Need for Speed” took more driving risks, had more traffic fines, and higher crash rates involving collisions with stationary objects (Hardigree, 2011). While the Continental Tyres survey was not conducted with an academic institution, the main results were reposted on over 25 high traffic websites (e.g., Fox News) with sensationalist titles such as, “Study Says Video gamers are Dangerous Drivers” (Fox News, 2011).

Video game violence has also been a hot topic for social science researchers, particularly in psychology with respect to the General Aggression Model (GAM) (Anderson & Bushman, 2001); Fischer, et al. 2007). Anderson and Bushman (2001),

explain that the underlying processes of aggression that have been identified with television and cinema violence are applicable to video game violence and have advocated for further investigation of the implications of violent video games. The prevalence of video game consumption in North America is high and the short and long term effects that video games have on learning, daily interactions, and cognition should be considered. However, rather than investigating violence, high-risk behaviour in regards to the driving context would be more appropriate.

The actual demographics of the video game population can be difficult to define, particularly due to the different media platforms that can be considered a video game. For instance, video games statistics often do not specify video game platform (PC, console, social media, and mobile device). Turning to industry statistics might provide better insight to gamer demographics. For instance, a sales and demographic report released in 2011 by the Entertainment Software Association (ESA) indicates that 72% of American households engage in video game play, of which 53% range between 18-49 years of age and 18% are under 18 years of age. The video game field is not necessarily a male dominated field anymore either; the ESA reports that the video game players have a gender divide of 58% males and 42% females. A break-down of North American video games by genre also indicates that games with a certain level of violence have greater popularity (the top six genres of video games by sales percentage in the total video game market in North America include: 21.7% Action, 16.3% sport related, 15.9% shooter, 7.7% role-playing, 7.5% adventure and 5.8% racing-related) (ESA, 2011).

A majority of video game research has focused on the relationship between first-person shooter video games and aggression; fewer studies have considered the

relationship between these violent games and high-risk driving behaviour. Whether video games result in high-risk and potentially dangerous driving behaviour is important to traffic safety. Aggressive driving behavior has been shown to increase crash risk (Fischer et al., 2007). Shope and Bingham (2008) state concerns that North American culture promotes unsafe driving behaviour to novice teen drivers and that racing games provide further encouragement to engage in unsafe and aggressive driving which will shape long term driving behaviour.

The current literature also indicates that racing video games might influence drivers to engage in high-risk driving scenarios, such as speeding, traffic violations and unsafe cross-traffic turns (Backlund, Engström, & Johannesson, 2006; Fischer et al. 2007). Investigating racing video games might reveal whether video game play has short or long term effects on a driver's high-risk behaviour, cognition and emotion and whether that puts gamers at a higher risk for traffic collisions and injury.

Beyond the scope of the negative effects of video games on social behavior, there is also growing interest in the positive effects of video games (Backlund, Engström, Johannesson & Lebram, 2012). Research has indicated that there is a relationship between playing video games and gains in visual search, anticipation, reaction time and hand-eye coordination (Zhang, et al. 2010). Video game play may influence driving performance by enhancing spatial relationships, reaction time, mental rotation, attention efficiency, problem solving, logical reasoning and visual processing (Green & Bavelier, 2003; Barlett et al. 2009; Zhang, et al., 2010). Determining whether or not cognitive gains from video game play translate into driving skill improvements could lead to application in driving education (VanEck, 2007).

Driving performance

Driving performance has been recognized as the product of driving skill (requiring perception, attention and motor control) and driving style (behaviours and habits influenced by personality characteristics and attitudes) (Elander, West & French, 1993). Driving style could be described as being fluid relative to driving performance and subject to influence and priming effects. In the domain of driving research, an error would be considered an unintentional skill-based error whereas a violation would indicate a deliberate and conscious choice to disobey traffic laws (McKenna, Horswill & Alexander, 2006). Not all driving errors are deliberate or intended and it can be difficult to determine whether an action was deliberate as the end result may be the same or because the distinction is irrelevant to law enforcers. For example, if a driver ran a yellow light, the behaviour might have been intentional or it might have been that the driver failed to notice the traffic signal changed. If violent video games actually influence driving performance, it would be assumed that driving style rather than driving skill would be affected.

Driving style

Driving style is comprised of many individual habits and behaviours that are influenced by personality characteristics and attitudes (Elander et al., 1993). Driving style does not refer to one's driving skill or ability, but rather the factors that influence how driving skills are utilized. Elander et al., (1993) further explains that driving style, particularly an inclination for high-risk driving behaviour, can override a person's actual driving skill. For example, an otherwise excellent driver that exhibits safe driving skills (e.g. adhering to the speed limit, steady control of a vehicle's lane position) may exhibit

poor driving skills if their driving style is influenced by violent and high-risk video games. If video games increase high-risk cognitions and affect, it is possible that video game play might alter driving style and result in a decrease of driving performance measures. Driving style might be more difficult to measure in the laboratory setting because participants might exhibit their best performance and be less inclined to behave as they would in their own vehicle.

General Aggression Model (GAM) and risk-taking behaviour

The General Aggression Model (GAM) presented by Anderson and Bushman (2001) offers a framework to understand how violent video games lead to aggressive cognitions, affect and behaviour. The GAM posits that “exposure to violent media increases aggressive behaviour through arousal, cognition and affect” (Carnagey et al., 2007). Anderson and Bushman (2001) explain that situational variables (e.g. recent violent video game exposure) influence a person to exhibit or experience aggressive cognitions, affect and arousal. Individual personality characteristics and situational variables influence internal states, cognitions and emotional affect, which in turn influence aggressive behaviour (Anderson & Dill, 2000). Basically, violent media is theorized to teach aggression and become a part of a person’s long term memory (i.e. schema). As a consequence of this, the theory suggests that aggressive schemata is more readily influenced and primed to aggressive situations. Anderson and Bushman (2001) also suggest that violent media has long term effects because repeated exposure leads to complex knowledge structures that influence a person’s personality and behaviour. Therefore, short and long term violent media exposure is believed to become internalized, particularly with children, and may result in an aggressive personality and behaviours.

The application of GAM to video games and driving behaviour could then investigate whether violent video games affect aggressive cognitions and aggressive affect, rather apply the model to investigate high-risk cognitions and affect. Anderson and Bushman's (2001) meta-analysis indicated that violent video games increase general aggression. The meta-analysis included journal articles that examined the effects of playing video games on aggressive cognition, aggressive affect, physiological arousal and pro-social behaviour. Video game violence was determined to be associated with heightened aggression in both experimental and non-experimental settings. Video game violence was further found to increase aggressive cognitions and affect in both males and females of all ages over a short term time period. Therefore violent video game exposure leads to participants thinking about aggressive scenarios and increased feelings of anger or hostility. However, thinking aggressive thoughts does not necessarily lead to aggressive behaviour or the intention to cause harm. Anderson and Bushman's (2001) meta-analysis also provided evidence that violent video game exposure might result in short term decrements in pro-social behaviour, though they did not have an adequate number of studies to establish this claim. A limitation of this meta-analysis was that it failed to identify the genre of video games included.

Specific to the driving domain, the GAM could be applied to high-risk driving behaviours and posit that video games would trigger risky ideas and cognitions and lead to high-risk behaviour (Bushman, 1998). Fischer et al., (2007) suggested that "cognitions, affect and behaviours related to risk-taking could be activated (primed) by the playing of video games"

(p. 23). Their predictions also suggested that high-risk behaviour primed through video

games could increase risk-taking behaviour in on-road driving situations (e.g., attempting a high-risk left turn crossing oncoming traffic, driving in excess of the posted speed limit where there is a potential for pedestrians to enter the roadway).

In line with GAM is the concept of “accessibility” in which the initial trigger of aggressive ideas increase the ease of which other aggressive cognitions, emotions and behaviours are accessed (Bushman, 1998). Boyce and Geller’s (2001) finding that drivers exhibiting one high-risk driving behaviour are more inclined to exhibit other high-risk driving behaviours (e.g. speeding, unsafe following/headway distances and off task behaviour while driving) supports the idea of accessibility.

Research on racing video games and risk-taking cognitions, affect and behaviour.

A series of studies (Fischer et al., 2007; 2009) took the conceptual model of the GAM and applied it to the investigation of risk-taking behaviour of drivers. These studies suggest that the high-risk media presented in racing video games can trigger risk-supportive cognitions and emotions that can increase risk-taking behaviour. This directly follows the GAM’s ‘formula’ that violent media increases aggressive cognition and emotion and leads to an increase in aggressive or violent behaviour.

The Fischer et al. (2007) research consisted of a series of three studies in Germany to evaluate the effect of racing video games on increased risk cognitions, affect and behaviours in relation to on-road driving. The three studies evaluated self-report data on video game exposure and examined how racing and neutral (non-driving related) video games influenced the accessibility of risk-taking cognitions and affect.

The first study (Study 1a) examined the self-reports of 198 males and 92 females with ages ranging from 16 to 45 years with regard to their racing experience and on

determinants of high-risk driving behaviour. These included constructs pertaining to competitive driving behaviour (e.g., racing others), intention to impress (e.g., engaging in driving stunts to impress others), attitudes toward cautious driving behaviour and reported number of accidents. The results indicated that playing racing video games was associated with a greater desire to impress others, greater competitiveness, reduced cautiousness and a higher number of reported accidents.

Fischer et al.'s (2007) second study (Study 2a) investigated whether playing racing video games increased general risk-promoting cognitions. A sample of 47 males and 36 females with ages ranging from 19 to 42 years played either a racing video game or a neutral video game (a video game that was non-violent and not driving-related) followed by the completion of a homonymous decision task (a task to define a homonym that can be described with an aggressive/risk-related definition or a neutral definition). The goal of the investigation was to determine whether racing video games prime and increase accessibility to negative cognitions as posited by GAM. Participants' arousal and their positive and negative affect (derived from the Positive and Negative Affect Scales) were also measured.

Results for Study 2a indicated that there was a main effect of video game type (racing or neutral) for both the accessibility of risk-related cognitions in the homonym decision task and on self-report measures of arousal. Specifically, participants who played a racing video game used more aggressive and risk-related definitions in the homonym decision task than participants who were in the neutral video game condition. This indicated that game play likely influenced negative cognitions. The researchers understood this result to indicate that the video games primed the participants' aggressive

schemata, which by extension, could lead to more aggressive or high-risk behaviour. However, the video game type condition did not find a significant effect on positive and negative affect, which was not explored further by the researchers.

Study 1a and Study 2a examined whether GAM theory applied to video game experience and exposure, but were not indicative of the participants' propensity to engage in actual high-risk behaviour. Fischer et al. (2007) recognized this shortcoming and designed a third study (Study 3a) to measure inclinations of risk-taking behaviour in critical driving scenarios. For Study 3a, the researchers used the Vienna Risk-taking Test for traffic (WRBTV). The WRBTV consists of 15 videotaped traffic scenarios recorded from the perspective of the driver and show critical traffic events which have the potential for high-risk outcomes. Scenarios are first described to participants, then the video scene is presented, the participants then watched the traffic scenario a second time and press a button to indicate when they would abort or report with a driving manoeuver. The amount of time it took a participant to abandon or intervene on a driving manoeuver in the WRBTV scenario assumed to measure an individual's willingness to take risks in dangerous driving scenarios. For instance, as the time to collision decreases (i.e. become more dangerous as the probability of a collision increases) the longer the participant waits to intervene and would indicate high-risk behaviour. Conversely, the quicker the participant indicated they would intervene would indicate a lower acceptance of risk and intervention before the participant would be at risk of a collision.

Study 3a recruited a sample of 29 males and 39 females to play either a racing video game or a neutral video game (non-driving games). Each video game condition included 3 different video games (3 racing video games and 3 neutral video games).The

neutral video game category include 2 puzzle games and 1 first-person shooter video game (the first-person shooter game was categorized a neutral because it's effects were not found to be statistically different from the 2 neutral puzzle video games on risk-related measures). After playing a racing or neutral video game, the participants completed the WRBTV followed by the homonym decision task that was used in the previous stages of the study.

Study 3a expanded on the results of the previous studies by including the behavioural component of risk-taking. After playing a racing video game, the participants who exhibited higher risk-taking behaviour on the WRBTV hazard perception scenarios (i.e. the participants took longer to respond to high-risk driving scenarios to indicate when they would abandon a high-risk driving manoeuver or perform a driving intervention). Additionally, players in the racing video game condition demonstrated greater accessibility to cognitions related to risk-taking in the homonym decision task. Male participants in the racing video game condition were found to exhibit significantly higher risk-taking behaviour (WRBTV) and risk related cognitions (homonym decision task). However, the video game by gender interaction was not found to be significant when age was controlled for as a covariate. The study by Boyce and Geller (2001) also failed to find gender differences in high-risk driving behaviour when ages were separated in specific age groups, but did find significant differences between the age groups. Overall, female participants were less influenced by racing video games compared to male participants, but this trend was not significant.

The three studies by Fischer et al. (2007) indicated that racing video games had social-cognitive priming effects. Overall, the results suggest that racing video games

increase risk-taking cognitions, enhance arousal, and increase risk-taking behaviours in critical driving scenarios. A limitation of studies 2a and 3a is that the video game condition occurred directly before the WRBTV condition and may lead to experimental demand effects. In summary, the research may only be indicative of the short-term effects of racing video game exposure rather than long-term behaviour. The effect of video games on behaviour may decay over time and the rate at which it decays is not known.

A series of 4 follow-up studies were conducted by Fischer et al. (2009) to further examine time delays and explain why racing video games increase propensity for risk-taking. The four studies utilized the WRBTV test to investigate the risk-taking behaviours in critical traffic scenarios. The research also sought to determine if racing video games alter an individual's self-perception in regards to being a reckless driver which in turn would influence risk-taking behaviour while driving.

Fischer et al.'s (2009) Study 1b used a time lag in the experimental design to determine whether risk-taking inclinations continued to be present approximately 24 hours after exposure to a racing video game. A sample of 11 males and 23 females were recruited to play either a racing video game or a neutral video game for 30 minutes and followed by the WRBTV either immediately or the next day (approximately 24 hours later). Participants also reported how arousing they found the video game through the use of a Likert scale.

The participants who played the racing video game in Study 1b trended toward higher-risk behaviour based on critical traffic scenario on the WRBTV after a 24 hour delay compared to the participants who played the neutral video game. The researchers

concluded that the increased tendency toward risk-taking in the critical driving scenarios was not due to experimental demand but rather to the effect of the racing video games.

A second study (Study 2b) (Fischer et al., 2009) investigated whether altered self-perceptions of being a reckless driver influenced the propensity for risk-taking behaviour in driving scenarios. A sample of 15 males and 16 females were assigned to play 20 minutes of either a racing or neutral video game. Videogame play was followed by a measure of their self-perception as a reckless driver and then the WRBTV to assess risk-taking inclinations in critical driving scenarios. The WRBTV was presented immediately to half of the participants who played the racing video game while the other half completed the WRBTV after a 15-minute delay. The participants also completed a risk promoting affect measure to determine their arousal level.

The results of Fischer et al.'s Study 2b (2009) once again indicated that racing video games increased risk-taking tendency on the WRBTV. Participants who were subject to the 15-minute time delay did not have significant differences in risk-taking driving behaviours compared to the group that immediately completed the WRBTV. The measure of self-perceived reckless driving also indicated that participants in the racing video game condition had greater perceptions of themselves as being a reckless driver than the neutral video game condition. The analysis also indicated that the participants' self-perception of being a reckless driver partially mediated the effect of racing video games on risk-taking in driving scenarios. The effect was assumed to be "partial" by the researchers because it was only marginally significant. Arousal ratings were not found to mediate risk-taking inclinations in traffic scenarios.

To build on the results of Study 2b, a third study (Study 3b) was designed to investigate whether racing video games that rewarded traffic violations and deviance resulted in greater risk-taking inclinations during critical traffic scenarios than racing video games that do not promote deviant driving behavior (e.g., Formula 1 racing video games that promote accuracy and speed, but not deviant driving behaviour). A sample of 27 males and 28 females with ages ranging from 20 to 46 years of age were randomly assigned either a street racing video game (that promoted and rewarded traffic violations and deviance), a racing video game (that promoted racing without traffic violence or deviance) or a neutral video game (no racing component). Some of the deviant traffic behaviour that was rewarded in the street racing video game included crashing into other vehicles, excessive speeding, and driving on pedestrian sidewalks. Once again, the participants' reported arousal level, self-perception of being a reckless driver and risk-taking inclinations in the WRBTV scenarios were collected.

The results of Study 3b (Fischer et al., 2009) indicated that participants who played the street racing video game had significantly higher risk-taking scores on the WRBTV than the participants who played the Formula 1 or neutral video game. Self-reports of perception also indicated that participants in the street racing video game condition were more likely to perceive themselves as being a reckless driver than in the other video game conditions. Further, the participants in the Formula 1 condition did not report a change in their perception of themselves as a reckless driver and were comparable to the participants in the neutral video game condition. A mediation effect for the street racing condition also indicated that the change in self-perception as a reckless driver likely resulted in their inclination to risk-taking in driving scenarios.

Fischer et al. (2009) completed a 4th study (Study 4b) to determine if observing video game play rather than actively engaging in video game play increased risk-taking inclinations. The WRBTV was used to assess risk-taking in driving scenarios, while blood pressure data was collected to determine arousal, and the homonymous decision task (as used in the Fischer et al. (2007) studies) was used to determine the accessibility of risk promoting cognitions.

The results of Study 4b indicated that the participants who actively played a street racing video game had higher risks scores on the WRBTV and identified themselves as a more reckless driver compared to participants who only observed the street racing video game. However, unlike the previous studies, self-reports of participants' perception of themselves as a reckless driver did not mediate the impact of the street racing video game on risk-taking. Further, in the street racing condition, the players and observers had similar increased levels of risk promoting cognitions, risk promoting emotions, sensation seeking scores and blood pressure. This indicated that playing a street racing video game resulted in greater risk-taking inclinations on the WRBTV's hazard perception scenarios despite similarity with other measures.

Fischer et al. (2009) findings indicated that video games that actively reward breaking traffic rules alter participants' perception of themselves as a reckless driver. However, a limitation of the research is that there is no on-road or simulated driving scenario to assess driving behaviours. This limitation is particularly detrimental because this relationship between racing video games and actual driving behaviour cannot be fully observed. In addition, the WRBTV primes participants to expect a high-risk scenario that requires their intervention (the participants are told to indicate when they would abort a

driving manoeuver by press of a button). An interactive driving simulation would allow participants to act and respond within a more realistic vehicle interface and driving environment, where high-risk scenarios would require appropriate responses and manoeuvers.

The effects of videogame experience

There is a lack of research studies that examine the actual driving behavior of video game players (gamers) in a controlled driving environment such as a driving simulator or instrumented vehicle. Self-report surveys can investigate video game experience, but few studies have actively attempted to recruit gamers as a sample group in simulated driving research. The results from the WRBTV risk-taking assessment in Fisher et al. 2007 & Fischer et al. 2009 studies show that video games, especially deviant street racing video games, can prime participants to exhibit high-risk-taking inclinations while driving. However, the studies did not account for the participants' video game experience prior to their involvement in the study.

Risk behaviour & sensation seeking. The hypothesis that video game effects go beyond game play and have indirect effects on facets of everyday life has resulted in an emerging interest in the effects of computer games on risk behavior in traffic (Fischer, et al., 2007; Backlund, et al., 2012). Specific to risk-taking, driving style has been found to be related to sensation seeking, (Zuckerman, 1979; Burns & Wilde, 1995) impulsivity (Wilson, 1990), aggressiveness (Arnett, 1996), external locus of control (Nowicki & Stricland, 1973), psychosocial influences associated with problem behavior (Jessor, 1987), and Type A personality (Geller & Boyce, 2001).

Sensation seeking, as defined as “a trait defined by the seeking of varied, novel, complex and intense sensations, experiences and willingness to take physical, social, legal and financial risk for the sake of such experiences” (Zuckerman, 1994, p. 27) Generally, sensation seeking has been correlated with numerous risk-taking behaviours, which include high-risk driving behavior such as speeding (Zuckerman & Neeb, 1980; Arnett, 1996; Jonah, 1997). Sensation seeking is of particular interest because individuals with high sensation seeking scores positively correlate with instances of speeding 20 km/h over the speed limit, street racing, illegal passing and driving while intoxicated (Arnett, 1996). Sensation seeking has been recognized for its strong relationship with high-risk driving behavior (Jonah, 1990).

Attitude & skill towards driving. Backlund, Engström, Johannesson and Lebram (2007) studied the relationship between games, traffic safety and traffic education to evaluate the practicality of developing a game-based driving simulator for educational purposes. The study collected data from students at three separate driving schools and had them rate their experience with racing, action and sports-related games. These self-reports were compared to the evaluation the driving students were given by their driving instructors and the effects of gaming experience on driving behavior were analyzed by group (e.g. gamer or non-gamer). The results indicated that gamers significantly outperformed non-gamers at having a higher capacity for divided attention and handling situations that required quick decisions as scored by their driving school instructors. However, this might have been due to demand characteristics and the gamer’s expectation that they would perform better than non-gamers.

In a follow-up study Backlund et al. (2010) investigated the learning effects of a driving simulator that had either a game element such as following an ambulance or no game element. Based on self-reports of game experience, the participants were grouped again as gamers or non-gamers and drove up to 30 minutes in a driving simulator. Traffic safety parameters such as speed, use of turn signal, headway distance, rearview mirror use, lateral lane position and lane change were evaluated. The general trend indicated that the gamers performed better than non-gamers at the traffic safety variable, however only headway distance and the number of lane changes were found to be significant in the game condition and the use of the rearview mirror was significant in the non-game condition. These results suggest that video games have a positive rather than a negative influence on traffic safety performance.

Limitations of current research

A limitation the current literature is that is does not investigate video gamers without video game condition that might prime or influence how they perceive the experimental environment. If video games do in fact have transfer effects to real world situations, those effects should be observable without an in-laboratory video game condition. The individual video game experiences of gamers and non-gamers should be investigated covertly as to not prime the experimental session. Fischer et al. (2007; 2009) investigated the relationship between playing racing video games and variables related to high-risk behaviour. The authors found that playing risk-oriented racing video games increased access to thoughts related to risk-taking, enhanced arousal, and increased risk-taking behaviours in driving-like tasks. They found that risk-taking behaviours were more prominent in male participants compared to female participants. A limitation of their

research is that participants only engaged in risk-related or driving-related tasks; participants never had the opportunity to drive. Thus, the causal relationship between racing video games and driving behaviour has not been adequately addressed. The purpose of the proposed research is to address this gap by investigating the relationship between the regularity of video game play outside of the laboratory setting with high-risk driving behaviour in a driving simulator.

Research proposal

Proposed study

The primary focus of this study is to examine the relationship that video game experience (regular and irregular video game play) has on driving behaviour in the University of Calgary Driving Simulator (UCDS). Specifically, do individuals that play a minimum of 5 hours of video games per week exhibit high-risk behaviour while driving. For example, would regular gamers be more likely to demonstrate high-risk behaviour when turning across traffic, running yellow lights, or tailgating slow moving traffic. Unlike previous research, this study sought to determine whether participants' self-reported video game play outside of the laboratory setting is related to high-risk driving behaviour. This study will control for demand characteristics and priming effects through covert recruitment and by not exposing participants to a video game condition in the laboratory setting. Further, this study will examine between-group differences of regular gamers (report consistently playing a minimum of 5 hours of video games a week) and irregular gamers (report inconsistent 'binges' of video game play, but had played less than 5 hours of video games within a month of their participation). Additionally, this study will examine whether personality traits, rather than video game play, is related to

high-risk behaviour in the driving scenarios (e.g. sensation seeking, risk-taking and driver confidence)

Previous research suggests that violent driving video games can increase risk-taking propensity, accessibility to violent cognitions and self-perceptions of being a reckless driver (Fischer et al. 2007; 2009). Others studies using self-report surveys found that gamers tend to report involvement in a higher number of traffic violations and vehicular collisions than non-gamers (Fischer et al. 2007; Hardigree 2011). Whether these results persist when regular gamers are compared to irregular gamers in a simulated environment is unknown.

This study proposes to compare the driving behaviour of regular and irregular gamers. The experimental driving scenarios will include 4 traffic events, including a reduced speed event, late yellow light, left turn across traffic at an urban intersection, a tailgating event and a pull-out vehicle incursion. The response to each event will be analyzed to determine whether participants exhibited high-risk driving behaviour. Of secondary interest is the participants' perception of the driving simulator's fidelity (whether the participant groups view the UCDS as a video game or similar to real driving).

The goals of the research are to examine:

1) Whether regular and irregular gamers' reported driving history differs.
2) Whether the recent and frequent video game play reported by regular gamers is related to high-risk driving behaviour in comparison to the irregular gamers in the simulated driving scenarios.

3) Whether regular and irregular gamers differ in how they adapt to the handling of the UCDS and perceived the UCDS's fidelity.

Hypotheses

Overall, the participants identified as regular gamers are expected to exhibit more high-risk driving behaviour in driving events where the participant must interact with programmed entities (virtual vehicles) in the virtual driving scenarios. However the regular gamers are expected to display better control of the UCDS in the baseline (BL) measures as well as events that do not require an interaction with a virtual entity.

1. Regular gamers are expected to adapt quicker to the UCDS than irregular gamers
    a. While regular gamers are expected to speed in excess of the posted speed limit, they are expected to have less speed variability, which indicates that they have better control over speed maintenance.
    b. Regular gamers are expected to have less lane variance (i.e., standard deviation of lane position (SDLP)) than irregular gamers, which would indicate that they are able to control the UCDS within the bounds of a lane with greater accuracy.
2. Regular gamers are expected to ignore or not adhere to changes in the posted speed limit compared to irregular gamers.
    a. Regular gamers are expected to have lower rates of deceleration when approaching a reduced speed limit sign.
    b. Regular gamers are expected to have significantly higher velocities than irregular gamers at the point where new posted speed limit is encountered.

3. Video game experience is expected to be predictive of anticipatory behaviours, decisiveness and high incidence of running yellow traffic lights.
    a. When approaching a ‘stale’ green traffic light (the traffic light has been green for a prolonged and unknown amount of time), the regular gamers are expected to accelerate in anticipation of the traffic light turning so as to enter the intersection before the traffic light turns. Irregular gamers are not expected to demonstrate anticipatory behaviour.
    b. Once the traffic light changes to yellow, the regular gamers are expected to run traffic light at the intersection. Irregular gamers are expected to exhibit indecisive behaviour by either tentatively braking or accelerating before choosing a course of action.
    c. Overall, the regular gamers are expected to run the yellow light significantly more frequently than the irregular gamers.
4. Video game experience is expected to be predictive of high-risk behaviour when making a left turn across oncoming traffic.
    a. Regular gamers are expected to make more left turns across oncoming traffic than irregular gamers.
    b. Regular gamers are also expected to complete the left turns at significantly shorter (high-risk) time gaps between oncoming vehicles.
5. Video game experience is expected to predict unsafe interactions with slow moving vehicles.
    a. Regular gamers are expected to follow (tailgate) slow moving vehicles at shorter headway times than irregular gamers.

6. Video game experience is expected to predict successful avoidance of an unexpected collision.
    a. Regular gamers are expected to avoid a collision with a pull-out car with greater success than irregular gamers. Further, the success of regular gamers to avoid a collision with a pull-out car is expected to be related to quicker perceptual response times.
7. The regular gamers are expected to perceive the UCDS to be less realistic and more like a video game because of their recent video game exposure. Because of this, it is expected that regular gamers will rate the simulator as unrealistic of real-world driving.
8. Regular gamers are expected to report a higher number of traffic accidents and traffic violations than non-gamers on the Driver Experience Questionnaire (DEQ).

Methods

Participants

Seventy-nine participants (41 males and 38 females) with a variety of video gaming backgrounds were initially recruited into in the study. All participants' ages ranged from 18 to 25 and had either a full class 5 license or a class 5 graduated drivers' license (GDL). All participants were recruited using the University of Calgary, Department of Psychology's research participation system, SONA. Participants were compensated for their time with class credit at a rate of 0.5 credits per half hour spent in the study.

Initial screening questions were used by the SONA system to screen participants based on video game experience. After arriving at the Cognitive Ergonomics Research

Laboratory (CERL), each volunteer signed an informed consent agreement (Appendix A) and their eligibility to participate was assessed. This included licensure, vision requirements for driving (i.e., 20/50 visual acuity) and no history of motion sickness. Participants with corrected visual acuity (e.g., glasses and contacts) were also included in the study.

All participants drove a 5-7 minute practice drive to assess whether they were prone to simulator sickness; 19 potential participants experienced symptoms of simulator sickness and did not complete the study. Two participants did not treat the study seriously and were dropped. The remaining 56 participants were categorized into groups as based on reported video game play.

Apparatus, materials and questionnaires.

Vision assessment. A Snellen Acuity Eye Chart, Vistech Contrast Sensitivity Chart and Ishihara plate no. 3 and 27 were used to assess each participant's vision. A greater description of these materials is provided in the procedure section.

Pre-Simulator Sickness Questionnaire. The Pre-Simulator Sickness Questionnaire (Pre-SSQ) (Kennedy, Lane, Berbaum & Lilienthal, 1993) (Appendix B) was used to screen participants for potential simulator sickness. Simulator sickness refers to symptoms similar to motion-induced sickness that can result in nausea or dizziness. Participants who answer 'yes' to any question on the Pre-SSQ questionnaire were warned that they may be prone to simulator sickness and given the option to withdraw from the study. This was done to prevent participants from experiencing nausea or discomfort.

Driving Experience Questionnaire. The Driving Experience Questionnaire (DEQ) (Appendix C) collected demographic information such as age, annual mileage,

number of traffic accidents, and number and type of traffic violations (Guppy, Wilson & Perry, 1990).

Sensation Seeking Questionnaire. The Sensation Seeking Questionnaire (Appendix D) measures an individual's willingness to engage in high-risk and sensation seeking behaviours (Zuckerman, 1979). Items on this questionnaire included: "I like wild 'uninhibited' parties" and "I sometimes like to do things that are a little frightening".

International Personality Item Pool subscale for Risk-taking. Ten scales items from the International Personality Item Pool Representation of the NEO-PI-R subscale for risk-taking (Appendix E) were included in the study (Goldberg et al., 2006). These items were presented on a 5 point Likert scale and were chosen for their similarity to the Jackson Personality Inventory (JPI-R) (r = .78). Items on this questionnaire include "Am willing to try anything once" and "Avoid dangerous situation" and required the participants to indicate how strongly he or she agreed with the statement**.**

Driver Confidence Questionnaire. The Driver Confidence Questionnaire (CQ) (Appendix F) required participants to rate their subjective confidence level as a driver in regards to different driving situations on a 7-point Likert scale (Senserrick & Swinburne, 2001). Items on this questionnaire included: "I am a better driver than others my age" and "I could still use more training".

Driving attitudes and behaviours. The Driving Behaviour Questionnaire (DBQ) (Appendix G) measures driver behaviours associated with different errors and violations (Reason et al., 1990). The questionnaire items cover five classes of aberrant driving behaviour (slips, lapses, mistakes, unintended violations and deliberate violations). While the DBQ was intended to investigate the drivers' distinction between traffic errors and

violations, it has also been used to predict accident involvement (de Winter & Dodou, 2010). Items on the DBQ include: “How often do you speed up in order to make it through yellow lights?” and “How often do you fail to notice a pedestrian crossing at an intersection?”

Post-Simulator Sickness Questionnaire. The Post-Simulator Sickness Questionnaire (Post-SSQ) (Appendix H is a variant of Kennedy et al. (1993) and assessed the extent that participants report symptoms of simulator adaptation syndrome (a.k.a., simulator sickness).

Media questionnaire. A Media Questionnaire (MQ) (Appendix I) was created for this study to collect information about each participant’s video game experience. The MQ asked participants to indicate how skilled they believed themselves to be at using different video game platforms, how many hours of video games they played over the past 24 hours, week, month,

6 months and year, which video game genres they preferred, and how seriously the participant regarded the UCDS during the experiment.

The University of Calgary Driving Simulator (UCDS)

The following description of the UCDS is abridged from Caird et al. (2006). The University of Calgary Driving Simulator (UCDS) is a moderate fidelity simulator integrated by DriveSafety and is located in the Cognitive Ergonomics Research Laboratory (CERL). The UCDS is composed of 5 Dell computers. A D-Link KVM switch handles the communication between the three 3.6GHz visual channels with a NVIDIA GeForce6600GT graphics cards linked to the three projectors. The 3.4 GHz authoring workstation is a development platform for the traffic scenarios and

experimental management; and the host computer (3.2 GHz) which manages I/O, graphics, audio (Audigy 2 sound card) and the SimObserver system. Each Epson 1720C projector displays (1064 x 768 resolution and maximum lumens 2700) onto a WrapAround Clarion Screen by Draper each of which measures 86.5” wide by 65”in height and are approximately 230cm from the drivers head position. The display refresh rate of the system is 60Hz. The total projected forward field of view from the drivers seated position is 150 degrees (Figure 1).

Figure 1. The UCDS complete configuration with vehicle and wraparound screens.

A Saturn SL1 is situated in front of the screens. The brake, accelerator, and steering are interfaced to the graphics by way of an A/D computer under the hood of the Saturn at 1200Hz. The steering wheel “stiffness” is controlled as a function of speed by a

torque motor (Model No. SE 808). Brake and accelerator inputs are modeled in software to result in appropriate deceleration and speeds. The speedometer (km/h), interior lights (i.e., dashboard, MP3/CD player), and fan provide speed, display information, and air respectively. Road noise is presented through a Monsoon MM2000 stereo system with base and surround speakers. Noise scales with the speed of the vehicle. Additional sounds can be attached to a range of events in the traffic environment.

Traffic environments and experimental scenarios for the driving simulator are developed and run in HyperDrive™ (v.1.9.28). The software uses a tile-based system to create visual worlds. Tiles can be selected from an extensive pallet of intersections, freeway sections, streets and so forth, all of which adhere to the Manual on Uniform Traffic Control Devices (MUTCD). Once a tile is selected it can be placed into an environment and linked with other tiles to compose a traffic environment. The placement of dynamic objects, such as vehicles and pedestrians, require iterative testing and development using a variety of Tcl/Tk scripts. HyperDrive™ also manages the data collection of a number of driving variables such as perception response time (PRT), velocity variability, minimum headway, and lane positioning. Programming of specific drives and events therein is described in the Procedures section.

Microphones mounted on the Saturn’s visors and a Yamaha speaker (Monitor Speaker, Model No. MS101 II) placed in the backseat allows participants and experimenters to communicate during the experiment. A Shure headset (Model No. BG3.1) is used by the experimenter to communicate with the participant, and input signals are controlled by a Behringer Eurorack mixer (MX802A).

Audio tracks are integrated with captured video of the driver into a single display. Two small black and white cameras (Model No. KPC 500) are mounted in the simulator and record the participant's face and upper body, and foot movement between the brake and accelerator. A stationary Panasonic camera (Model No. WV-CP460 with a WVLA 9C3A 9mm Panasonic lens), is mounted above the simulator and provides a forward view of the center screen and driving environment. The images captured by these three cameras are combined using a Sanyo multiplexer (Model No. MPX-CD4) and displayed on a 27" Sony Wega LCD TV and a 19" monitor connected to the simulator. The fully integrated medium is captured by a SimObserver system at a rate of 30 Hz and analyzed using Data Distillery from RealTime Technologies.

UCDS driving scenarios

Three driving scenarios (practice scenario, scenario 1 and scenario 2) were created and programmed for the study. A scenario refers to the entire programmed drive (start to finish) including all driving events (e.g. late yellow light event where the participants' driving behaviour is actively being collected for analysis) as well as the non-events (e.g. driving between driving events). The participants who drove the three driving scenarios in the same order.

The driving scenarios included a variety of roadways environments such as, urban, rural, industrial, and freeway environments. Urban driving environments had either two or four lanes of traffic, parked vehicles along the roadways, commercial buildings and storefronts and posted speed limits of 50km/h or 70 km/h (Figure 2). Industrial and rural environments had two or four lanes of traffic, posted speeds of 70km/h and had industrial buildings, parking lots, storage sheds, and grain elevators

present (Figure 3 & Figure 4). Finally, freeway roads consisted of four lanes of traffic (two lanes in each direction) separated by a concrete median and had a posted speed of 90km/h (Figure 5). A residential environment was only present at the very start of the practice drive (less than a minute of total driving time) and consisted of two lanes of traffic, a posted speed of 50 km/h and a row of bungalow houses.

Figure 2. Sample of an urban roadway in the virtual environment.

Figure 3. Sample of an industrial roadway in the virtual environment.

Figure 4. Sample of a rural roadway in the virtual environment.

Figure 5. Sample of a freeway in the virtual environment.

Ambient and oncoming traffic was present on all roadways and consisted of various cars, trucks, SUV's and commercial vehicles. These automated vehicles would travel a linear path and would be generated and destroyed at coordinates not visible to the participant driver. On non-linear roadways, such as freeway environments, vehicles were manually programmed to traverse the roadway in a manner that resembled traffic behaviour.

Vehicles that traveled in the same direction as the participant had to be manually programmed so that they would not interfere with the path of the participant. On freeway, rural and industrial road environments, automated vehicles were programmed to travel within 10 km of the posted speed limit and were visible ahead of the driver or behind the driver in the rearview mirror. In the urban driving environments a 'lead' vehicle was present on a number of routes and travelled consistently at either 50 km/h or 60 km/h.

These lead vehicles were programmed to travel at least 100 metres ahead or behind the participant before turning and taking a different route. These lead vehicles were not intended to interact with the participant and were included to make the driving scenario believable. If the participant drove significantly over the speed limit, it was possible to catch up with the lead vehicles as their speed was constrained to programming.

UCDS practice scenario. The practice scenario took approximately 5 to 7 minutes to complete and allowed the participants to become acquainted with the handling characteristics of the UCDS vehicle and the visual graphics. The researcher explained the basic handling of the vehicle (e.g. steering, gear shift, brake, and accelerator) and pointed out the placement of the speedometer, rearview and side view mirrors for the UCDS. Participants were instructed to drive as they normally would in their own vehicle, but were not given instructions about ‘obeying’ the rules of the road. The practice scenario included similar terrains to those that appeared in the subsequent experimental scenarios. There were no driving events in the practice scenario; however, baseline (BL) measures were included throughout the scenario to assess how well the participants adapted to handling the UCDS. The BL measures collected data on speed and lane position. Figure 6 provides a map and route of the practice drive as well as the zones where the BL measures were collected.

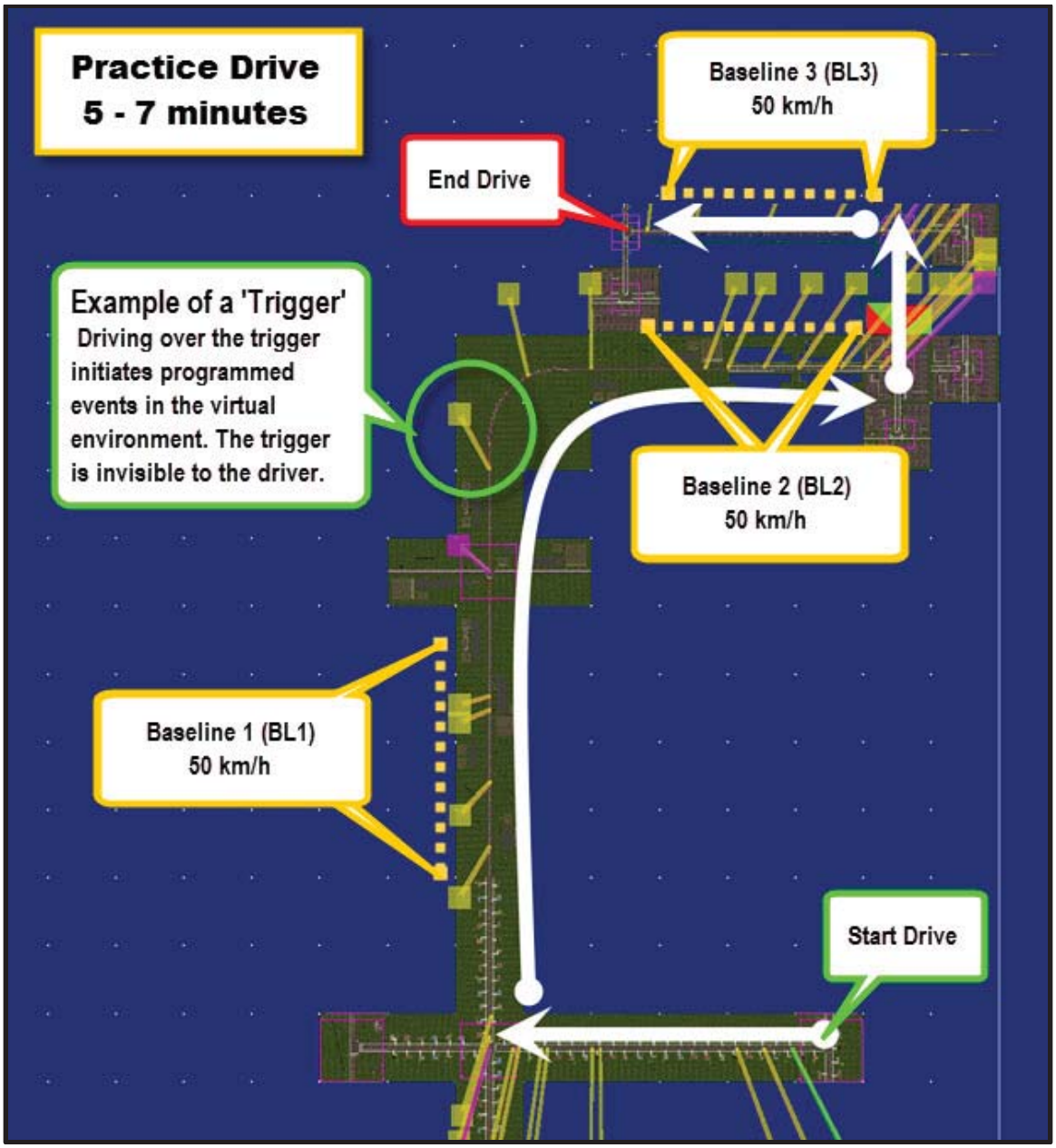

Figure 6. Complete map & route of the practice scenario.

UCDS experimental scenarios. Two experimental scenarios and were composed of rural, urban, industrial and freeway environments and took approximately 12 to 18 minutes to drive. Participants were told to follow directional text prompts on screen when they were presented, but to otherwise drive as they normally would in their own vehicle. Between each experimental scenario, the participants were given the option to take a break before continuing the driving portion of the study.

During the experimental scenarios, participants encountered both expected driving events (routine traffic occurrences that drivers are able to anticipate such as a yellow light or completion of a left turn with oncoming traffic) and an unexpected event (traffic occurrences that do not have advanced warning cues such as a vehicles pulling into traffic without notice). BL measures also collected data on speed and lane position throughout the experimental scenarios to examine how the participants handled the UCDS. Figure 7 and Figure 8 provide a map, route and the placements of the BL measures and driving events within the driving scenario.

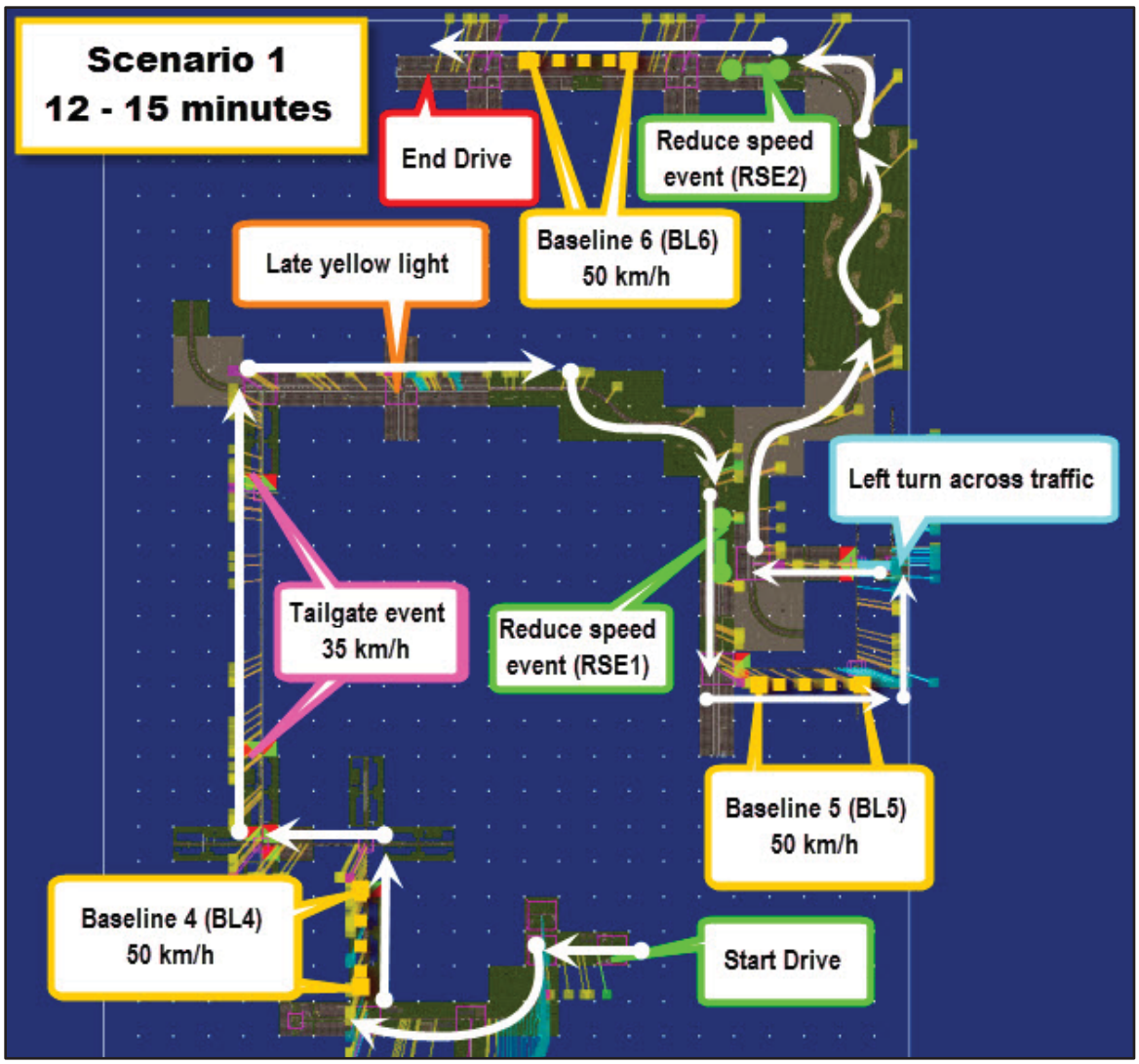

Figure 7. Complete map and route of the first experimental driving scenario.

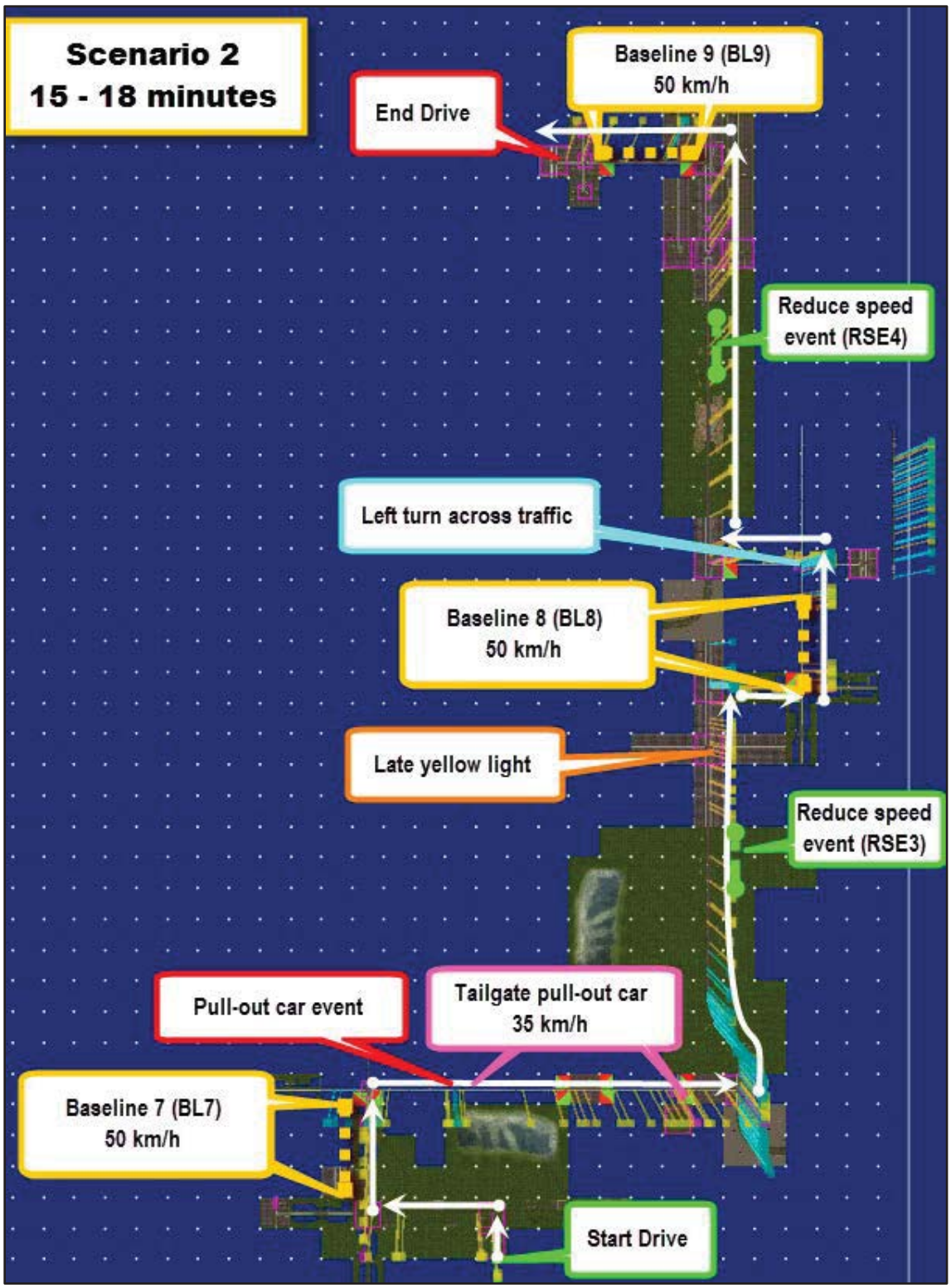

Figure 8. Complete map and route of second experimental driving scenario.

Driving events

Reduced speed event. The speed reduction event occurred twice in each experimental scenario on a straight stretch of roadway that transitioned from a freeway to urban driving environment (Figure 9). In this transition zone, the participants drove from a 90 km/h speed zone to 70km/h speed zone. A sign that read “Reduced Speed Ahead” was present 150 meters before the new posted speed of 70 km/h. The purpose of this event is to analyze whether the participants decelerated to adhere to the new posted speed limit.

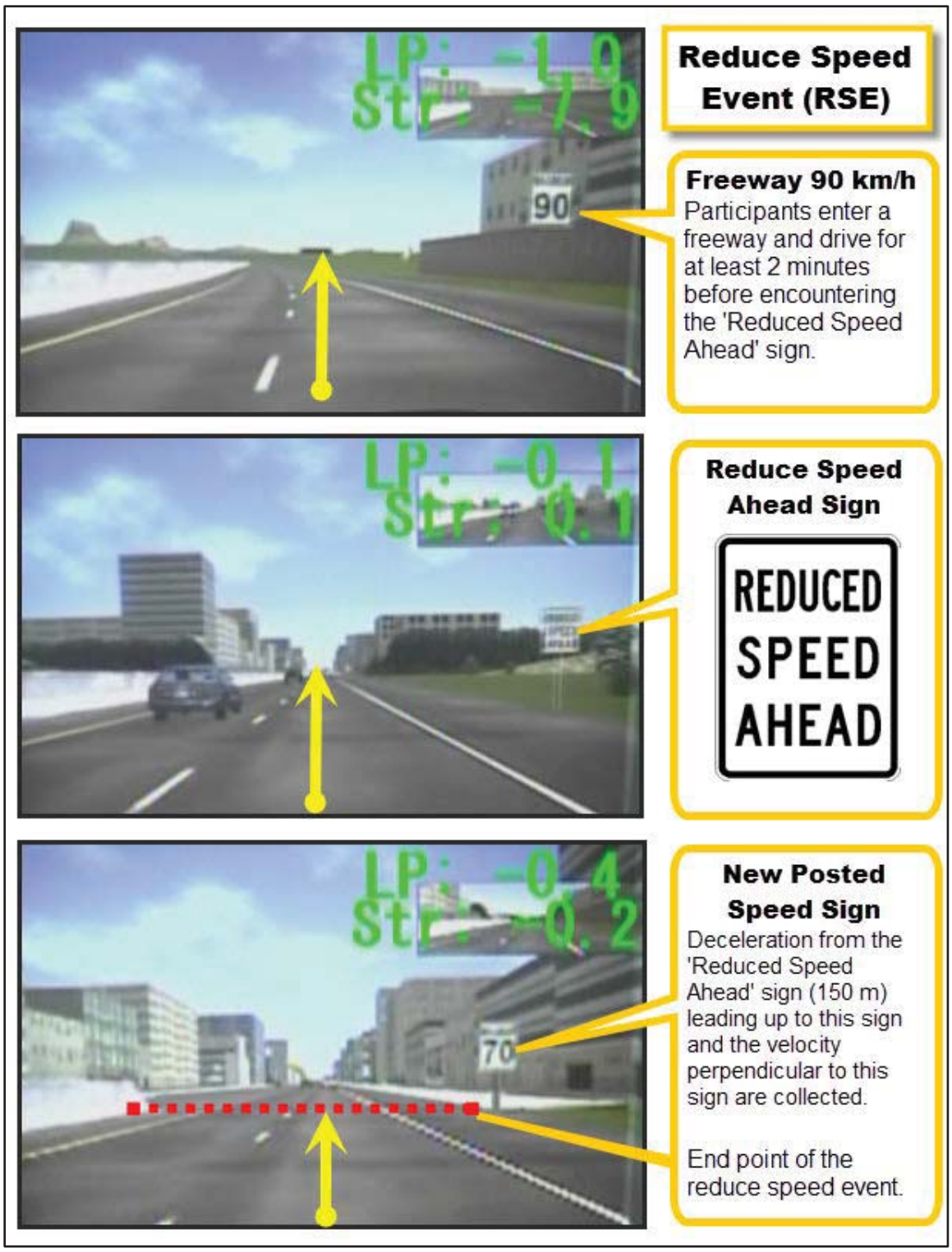

Figure 9. Speed reduction event from a 90 km/h freeway to 70 km/h urban road.

Late yellow light event. In both experimental scenarios, the participants encountered a traffic light that changed from green to yellow when the vehicle was 2.21 seconds away from the intersection stop line (Figure 10). This event occurred in a 70 km/h urban driving environment and was activated when the participant drove over an invisible trigger. The participant's speed at the time of the event activation determined when the traffic light changed to yellow so all participants were afforded 2.21 seconds to respond (Milloy, Caird, Ohlhauser & Pearson, 2010). The participants had to decide whether to brake hard to stop or run the yellow light and continue through the intersection.

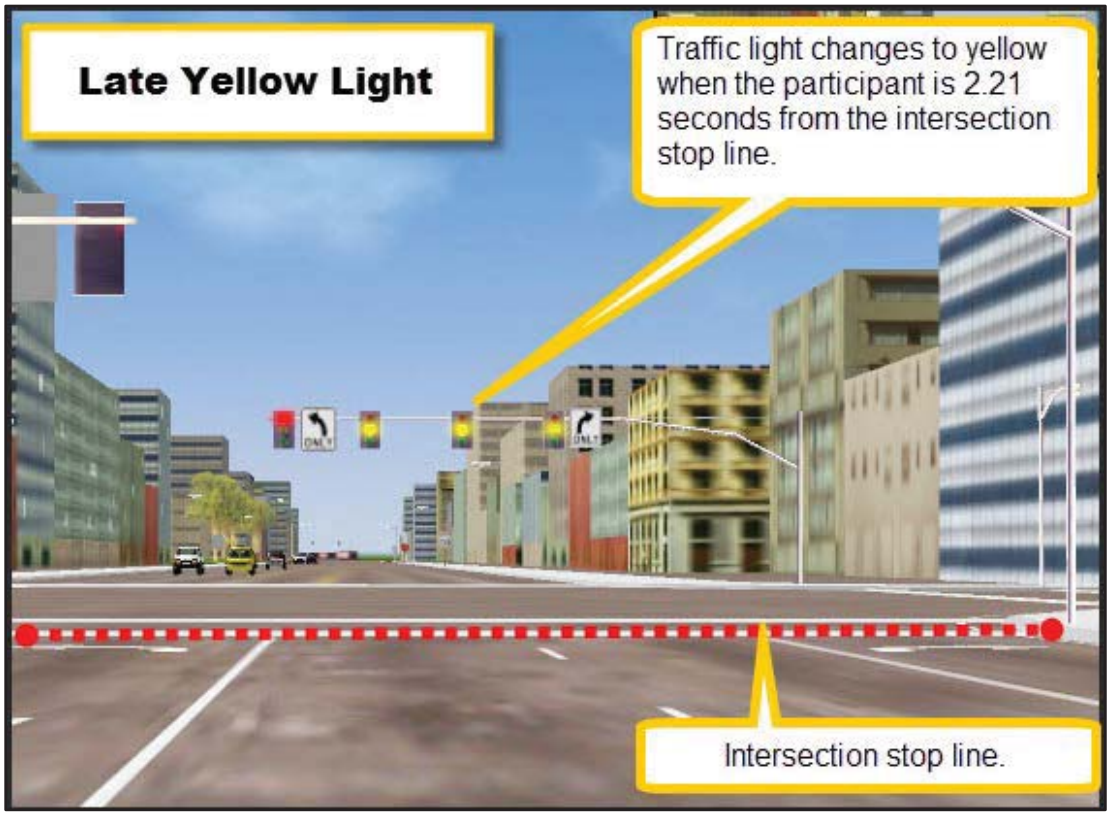

Figure 10. Late yellow light at an urban intersection.

Left turn and gap acceptance with cross-flow traffic. In both of the experimental scenarios, the participants had to compete a left turn at an intersection with oncoming traffic present (Figure 11). The intersection had two lanes; each lane travelling in opposite directions. This event would initiate when the participant approached an intersection with a red light that would turn green once the participant reached the intersection stop line. An invisible trigger was placed at the stop line and would signal the traffic light to turn green and activate the oncoming traffic. The oncoming traffic consisted of cars, trucks, and SUVs that travelled at 60 km/h on a linear path through the intersection. A total of nine cars traversed the intersection, each with a widening time gap that increased by 0.5 seconds between the lead vehicle's back bumper and the following car's front bumper (2.5-6.5 second time gaps). The participant could choose to complete the left turn during one of these time gaps or wait until all of the traffic had passed through the intersection (approximately 45 seconds after the event was triggered).

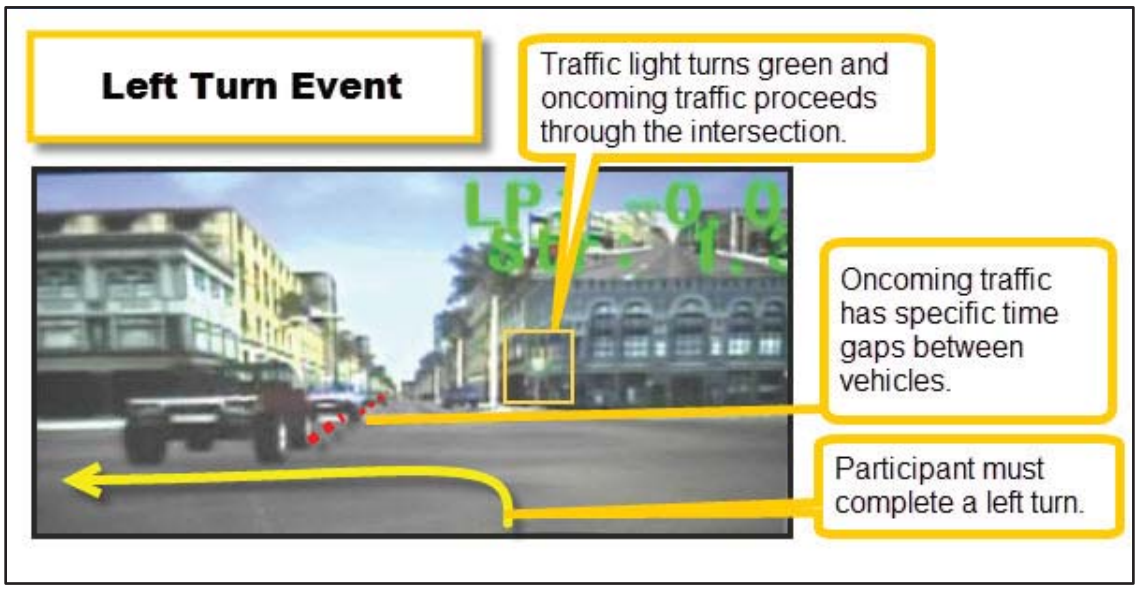

Figure 11. Left turn gap acceptance with oncoming traffic.

Vehicle tailgate & pull-out car events. In the first experimental scenario, the participant would encounter a red car driving 35 km/h on an urban roadway with a 50 km/h posted speed (Figure 12). This slow vehicle activated when the participant drove over an invisible trigger at the peak of the hill, the slow vehicle would then join the roadway at the base of the hill. This slow car was programmed to maintain a constant 35 km/h speed for 800 meters and would then accelerate to the posted speed limit of 50 km/h for an additional 200 meters before it would make a right turn at an intersection.

Figure 12. Slow moving vehicle travels at 35km/h in the tailgate event.

In the second experimental drive, a parked vehicle would cut into the roadway directly in front of the participant (Figure 13). This event activated when the participant drove over an invisible trigger 20 meters from the pull-out vehicle in a 50 km/h speed zone. The pull-out vehicle would cut into the participants' driving path at an acceleration rate of $3m/s^2$ and continue to accelerate until it reached 35 km/h. This event provided the participant with approximately 1.5 seconds (time to projected collision if the participant drove at the posted speed limit) to brake or maneuver the UCDS to avoid a rear-end collision. This pull-out vehicle then behaved similar to the slow car in the first tailgate event (travelling 800 meters at 35 km/h before accelerating to 50 km/h for 200 meters).

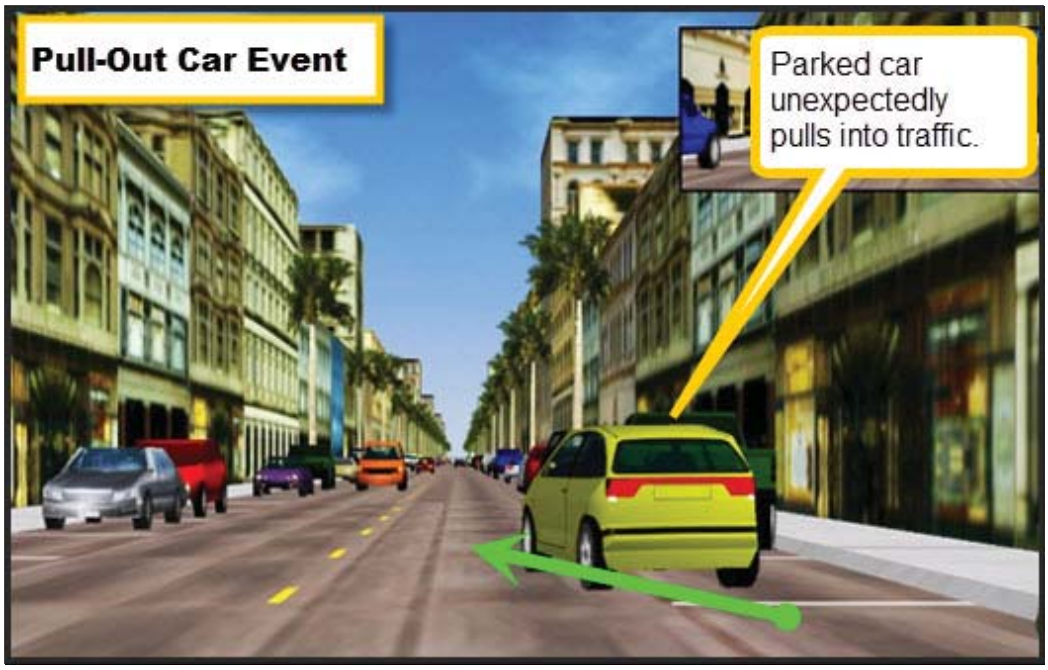

Figure 13. Pull-out vehicle unexpectedly pulls into the path of the participant driver.

Procedure

Informed consent and questionnaires. All participants were given an informed consent document to read and sign when they first arrived to the research session. Participants were then asked to provide proof of licensure to continue in the study and completed 6 questionnaires (Pre-SSQ, DEQ, DBQ, SSS, IPIP-Risk and DCQ). The researcher reviewed the Pre-SSQ with each participant to ensure that he or she was a good candidate to participate. If the participant had indicated a history of motion sickness on any of the Pre-SSQ items, they were informed of their elevated risk for experiencing discomfort in the UCDS.

Vision testing. After filling out the questionnaires, participants had their visual acuity, contrast sensitivity and ability to discriminate colour assessed. Visual acuity was assessed for the left and right eye separately (monocular test) to ensure participants had 20/50 visual acuity or better as required by Alberta's minimum vision requirements for

class 5 licensure (CCMTA, 2011). Each participant stood 6.1 meters (20 feet) away from the standard Snellen Acuity eye chart and use an optical occluder to cover one eye and read aloud letter sequences in descending size until they were no longer able to decipher the letters. The researcher recorded the last row that the participant was able to successfully read without error as their visual acuity

Contrast sensitivity was assessed with the Vistech Contrast Sensitivity Chart. This binocular test required participants to report the orientation of a gradient of lines (up, right or left) at a distance of 3 meters (9.8 feet). Finally, the participants were presented with plate no. 3 and 27 of the Ishihara Test for Colour Blindness (Ishihara, 1993). This study screened for individuals with colour deficiency because some of the traffic events required color discrimination of traffic lights. Participants who met all vision requirements were introduced to the UCDS.

Driving portion. All participants were instructed how to operate the UCDS and asked to drive as they normally would in their own vehicle. After the initial practice scenario, the researcher checked in with the participants before continuing onto the following experimental scenarios. Participants were offered a break between each driving scenario as total driving time in the UCDS ranged from 27-40 minutes. Participants who chose to withdraw from the study during any driving scenario were asked if they would complete SSQ and MQ before being debriefed.

Final questionnaires and debrief. After the driving portion was completed, the participants completed the Post-SSQ, and the MQ. The participants were then debriefed about the purposes of the study (Appendix J) and allowed to ask any questions regarding the study once the research session was completed.

Results

Participants

Seventy-nine recruits entered the experimental session, of these, two were used as pilots (one male and one female), 56 successfully completed all components of the study, 19 withdrew due to simulator sickness, and two were removed from analysis. The participation of these pilot participants lead to minor changes in the design of the research scenario (e.g. language protocol to introduce the UCDS, placement of event triggers in the virtual environment and correction of programming errors in the virtual environment); their data is not included in the final analysis. Four males and 15 females withdrew from the study after experiencing symptoms of simulator sickness. Many of these participants explained that they felt the onset of a headache, experienced eyestrain or nausea and did not want to continue. The participants who experienced simulator sickness will be further examined later in this paper. The two participants who were removed from the analysis were excluded because they did not take the research scenario seriously. These participants operated the driving simulator as if it were a toy (i.e. they drove through other vehicles, drove the UCDS at its top speed, 120 km/h in a 50 km/h zone and ignored the majority of traffic signs); their data is not included in the final analysis.

Video game experience of viable participants. Originally, the participants who completed the entire experimental session were going to be assigned to one of two groups: gamers and non-gamers. These groups were going to be categorized based on pre-screen results from SONA (University of Calgary's research participation system) and self-reports of video game experience collected by the MQ. However, self-reports on

the MQ indicated that the amount of time that participants played video games was quite variable throughout the year and many game players had “binges” in video game play (e.g. during summer vacation, or after the release of a new title). Alternately, some gamers abstained from video games because of their university schedule (e.g. midterms and final exams). In addition to variable video game play, a number of participants who were expected to be gamers or non-gamers from the SONA criteria were actually the opposite. For example, females who reported playing at least an hour of video games on the SONA system reported negligible amounts of video game play in the experimental session and males that reported less than an hour of game play were more likely to be irregular video gamers that reported “binges” of video game play. The participants were categorized into three core groups to account for the variation and unexpected discrepancies of reported video game play: regular gamers, irregular gamers and non-gamers (Table 1).

Table 1
Description of participant groups based on frequency and regularity of video game play on PC and console platforms.

Group	**Description**
Regular gamers	Regular gamers reported playing a minimum of 5 hours of video games within a week of participating in the research study, an average of 5 hours of video game play per week in the past month of participating in the research study and reported a consistent routine of video game play in the past 6 months.
Irregular gamers	Irregular gamers reported playing less than 5 hours of video games within a week of participating in the research study and played less than 20 hours of video games within a month of participating in the study. However these participants reported "binges" of video game play in the past 6 months of study and indicated that there were times of the year that they tended to play more video games.
Non-gamers	Non-gamers reported playing less than 20 hours of video games in the past 6 months. These individuals also indicated that they did not considered themselves to be "gamers" and indicated that they were less skilled at playing console and PC video games as compared to the regular and irregular gamer groups.

The participants were then categorized according their video game experience and gender composition was examined**.** The groups did not have an adequate gender division. Specifically, females were overrepresented in the non-gamer group (83. 3% female) and underrepresented in the regular gamer (23. 0%) and irregular gamer (9.5%) groups (Table 2). The analysis of how video game experience is related to high-risk driving behaviour would then be compromised by a gender effect. Because of the gender imbalance the original hypotheses and objectives were altered from analyzing gamers and non-gamers (male and female) to analyzing only male regular and irregular gamers. Female non-gamers were later analyzed, but no specific inferences could be made as to whether group differences were due to effects of gender or video game experience. The effects of video game experience between male regular and irregular video game players on high-risk driving behaviour became the focus of the analysis.

Table 2
Summary of video game play and perceived skill for each gamer category.

			In the past:				Skill	
		N	**24 Hours (SD)**	**Week (SD)**	**Month (SD)**	**6 Months (SD)**	**PC (SD)**	**Console (SD)**
Non-gamers	**Male**	4	0.67 (1.15)	0.00 (0.00)	1.00 (1.00)	11.67 (8.50)	1.67 (1.15)	2.33 (1.52)
	Female	15	0.00 (0.00)	0.36 (1.08)	0.75 (1.25)	3.64 (4.24)	1.87 (0.83)	2.0 (0.76)
Irregular gamers	**Male**	18	0.38 (0.68)	1.78 (1.86)	9.72 (6.52)	95.83 (89.96)	1.94 (0.53)	2.94 (0.87)
	Female	2	1.00 (1.41)	1.00 (1.41)	14.00 (5.66)	56.00 (33.94)	2.50 (2.12)	2.50 (0.71)
Regular gamers	**Male**	13	2.73 (2.39)	10.27 (5.64)	46.92 (26. 2)	314.62 (213.28)	3.38 (0.65)	3.15 (0.90)
	Female	3	2.00 (0.00)	5.00 (1.00)	33.33 (23.09)	166.67 (204.29)	2.00 (1.00)	3.00 (0.00)

The final primary participant sample consisted of 31 males (13 regular gamers and 18 irregular gamers). The secondary sample consisted of 15 female non-gamers. The remaining 10 participants were excluded from analysis due their small sample size (four male non-gamers, two female regular gamers and four female irregular gamers).

Male gamer participants (regular and irregular)

Thirty-one male participants had their simulator driving performance assessed to determine whether video game play was related to high-risk driving behaviour. Male participants formed two groups: 13 regular gamers aged 18 to 22 years (M = 19.69, SD =1.18) and 18 irregular games aged 18 to 25 years (M = 20.00, SD = 1.94).

Driving history. The majority of participants were unable to provide a reasonable estimate of how many kilometres (km) that they drove (weekly, monthly or yearly) and for this reason the length of licensure in months (from learner's license to present) was used as a measure of driving experience. The number of traffic accidents and violations

were also examined for each group and are summarized in Table 3 along with the participants' visual acuity required for licensure.

Table 3
Summary of the participant's driving experience and visual acuity.

			Past 5 Years			**Visual Acuity**	
	N	**Length of Licensure (SD)**	**Vehicular accidents (SD)**	**At fault accidents (SD)**	**Traffic violations (moving)(SD)**	**Left eye (SD)**	**Right eye (SD)**
Regular gamers	13	41.92 (15.89)	0.23 (0.44)	0.15 (0.38)	1.62 (2.75)	1.41 (0.83)	0.28 (0.75)
Irregular gamers	18	55.22 (29.49)	0.44 (0.70)	0.22 (0.55)	1.72 (2.35)	1.24 (0.65)	1.21 (0.40)
Total sample	31	49.65 (25.27)	0.35 (0.61)	0.19 (0.48)	1.68 (2.48)	1.30 (0.71)	1.29 (0.57)

A forward stepwise logistic regression (stepwise-LR) was conducted to determine whether driving experience, the number of vehicular accidents, at fault accidents and traffic violations were predictive of gamer type. However none of the variables improved the null classification model indicating that the regular and irregular gamers did not have significantly different driving histories pertaining to accidents or violations (Table 4).

Table 4
The significance level of each predictor variable for gamer type.

Predictor variable	**Significance level**
Length of licensure	$p = 0.14$
Number of vehicular accidents (past 5 years)	$p = 0.33$
At fault accidents (past 5 years)	$p = 0.69$
Traffic violations (moving) (past 5 years)	$p = 0.90$

Video game experience.

In terms of video game experience the regular gamers not only reported greater amounts of video game play, they also reported greater perceived skill on the MQ (Appendix I) at playing video (on a scale where 1 indicated 'not skilled at all' and 4

indicated ‘very skilled’). Regular gamers rated themselves as having greater skill on PC video games (*M* = 3.38, *SD* =0.65) and console video games (*M* = 3.15, *SD* = 0.92) than did irregular gamers on PC video games (*M* = 1. 94, *SD* =0.53) or console video games (*M* = 2.94, *SD* =0.87). The participants’ most recent 6 video games titles were also examined (Table 5). All 13 regular gamers listed at least one recently played video game that was rated “M” (mature) for intense violence by ESRB guidelines (blood, gore, strong language, suggestive themes and use of drugs were also common themes cited for mature ratings). The overwhelming majority of irregular gamers (15 of 18 participants) also reported playing at least one video game rated “mature” for intense violence. Of the three remaining irregular gamers, one participant listed a video game rated “T” (teen) citing violence, while the other two participants only listed sport or racing related game titles rated “E” (everyone).

Table 5
Most recently played video games titles/franchises by participants.

Title/Franchise	Frequency		Title/Franchise	Frequency	
	Regular gamer	**Irregular gamer**		**Regular gamer**	**Irregular gamer**
Mature Rated Games					
The Elder Scrolls V: Skyrim	4	7	*Dishonored*	1	0
Halo Franchise (2, 3, 4)	4	3	*Fallout 3*	1	0
Call of Duty Franchise (Black Ops, Black Ops 2, Modern Warfare 2, Modern Warfare 3)	3	10	*No More Heroes*	1	0
Assassin's Creed (1,2, Brotherhood)	3	3	*Red Dead Redemption*	1	0
Counter-Strike Franchise (Source, Global Offense)	3	2	*Team Fortress 2*	0	3
Borderlands Franchise (1,2)	3	1	*Resident Evil Franchise (4, 6)*	0	2
Mass Effect Franchise (2, 3)	3	0	*Walking Dead*	0	2
Battlefield 3	2	0	*Age of Empires*	0	1
Team Fortress 2	2	0	*God of War 3*	0	1
Fallout Franchise (3, New Vegas)	1	2	*Grand Theft Auto 4*	0	1
Diablo 3	1	1	*Left 4 Dead*	0	1
Amnesia Dark Descent	1	0	*Shin Megami Tensei: Persona 3*	0	1
Defense of the Ancients	1	0			
Teen Rated Games					
Starcraft 2	2	1	*Uncharted 3*	1	0
Forza Horizon	2	0	*World of Warcraft*	1	0
Guild Wars 2	2	0	*Final Fantasy X-2*	0	1
League of Legends	2	0	*Last Story*	0	1
Batman Arkham City	1	1	*Midnight Club*	0	1
Star Wars: Old Republic	1	1	*Okami*	0	1
Super Smash Bros Brawl	1	0	*Portal 1*	0	2
Terraria	1	0	*UFC Undisputed*	0	1

Test Drive Unlimited 2	1	0			
Everyone Rated Games					
NHL Franchise (11, 12, 13)	*2*	*4*	*Braid*	*1*	*0*
Super Mario Bros	*1*	*1*	*Bastion*	*1*	*0*
MarioKart	*1*	*1*	*Madden NFL Franchise (11, 12)*	*0*	*3*
Wii Sports	*1*	*0*	*NBA 2K13*	*0*	*2*
Portal 2	*1*	*0*	*Tetris*	*0*	*1*
Gran Turismo 5	*1*	*0*	*NCAA Football 2013*	*0*	*1*
Forza Motorsport 4	*1*	*0*	*FIFA 2013*	*0*	*1*
Burnout Paradise	*1*	*0*	*F1 2010*	*0*	*1*

Driving and racing video games were not found to be particularly popular with the recruited sample. Eight regular gamers and eight irregular gamers indicated that they had played at least one driving/racing related videogame in the past six months. Table 6 provides a list of the reported driving/racing video games played by the participants within six months of the study.

Table 6
List of driving/racing related video game titles played by participants.

	Frequency	
Title / Franchise	**Regular gamer**	**Irregular gamer**
Forza Motorsport Franchise (1,3,4,Horizon)	5	1
Need For Speed Franchise(1, Shift2, Underground)	3	3
Gram Turismo 5	2	2
Burnout Paradise	1	1
MarioKart	1	1
Initial D	1	0
Juiced 2	1	0
Test Drive Unlimited 2	1	0
Crazy Taxi	0	1
Dirt	0	1
F1 2010	0	1
Grand Theft Auto 4	0	1
Midnight Club Dubbed	0	1

UCDS adaptation and vehicle control.

The baseline (BL) driving measures collected in all three driving scenarios (practice drive, scenario 1 and scenario 2) were analyzed using a 2 [gamer type] x 9 [BL] repeated measures (RM) ANOVA (with the BL variables as the within-subjects variable). The focus of this analysis was to determine whether the regular gamers adapted to handling the UCDS quicker and drove the UCDS more consistently than irregular gamers. The data from one participant is missing from the RM ANOVA due to a failure of data collection in the practice drive in which the collection file was corrupt and could not be accessed. Between-subjects factors of gamer type (regular, irregular gamers) were the primary interests for this study. Within-subject factors of BL measures (variables that included speed, speed variance, and lane position) and interaction effects (gamer type by BL measure) were also examined. The BL measures were collected over nine 400 metre

stretches of roadway in 50 km/h urban speed zones (refer to Figure 6, Figure 7 & Figure 8). The practice, first and second experimental drive scenarios each included three BL measures.

Average speed. Average speed was calculated for each participant over a straight 400 metre stretch of roadway in urban or industrial driving environments. These BL measures of average speed were analyzed using a 2[gamer type] by 9 [BL-average speed] RM ANOVA (with average speed as the within-subject variable). Neither the between-subject effect of gamer type ($F(1, 28) = 0.37$, $p = 0.55$), nor the gamer type by BL measure interaction ($F(4, 112) = 1.92$, $p = 0.11$) was significant. Therefore the regular gamers (M = 53.9 km/h, SE = 0.90) were not found to significantly differ in average speed from irregular gamers (M = 54.8 km/h, SE = 0.96).

A Greenhouse-Geisser (G-G) corrected RM ANOVA determined that within-subject effects of BL measure were present which indicated that the average speed for regular and irregular gamers differed significantly across the BL measures ($F(2, 1351) = 378$, $p < 0.001$) (Figure 14 demonstrates the pattern of average speeds across BL with an origin of 0, while Figure 15 provides the pattern across BL within 50 km/h – 60 km/h). Post-hoc tests revealed that regular gamers had five instances where within-group BL measures were significant ($p < 0.05$) with a Bonferroni correction (Table 7), whereas the irregular gamers had 14 instances where within-group BL measures differed significantly (Table 8). How when the average speed at each BL measures was considered, the results may not have practical significance. This is because all significant differences were within 10 km of the posted speed limit and had lower mean difference ranging from 2.6km/h – 8.5 km/h (Table 9).

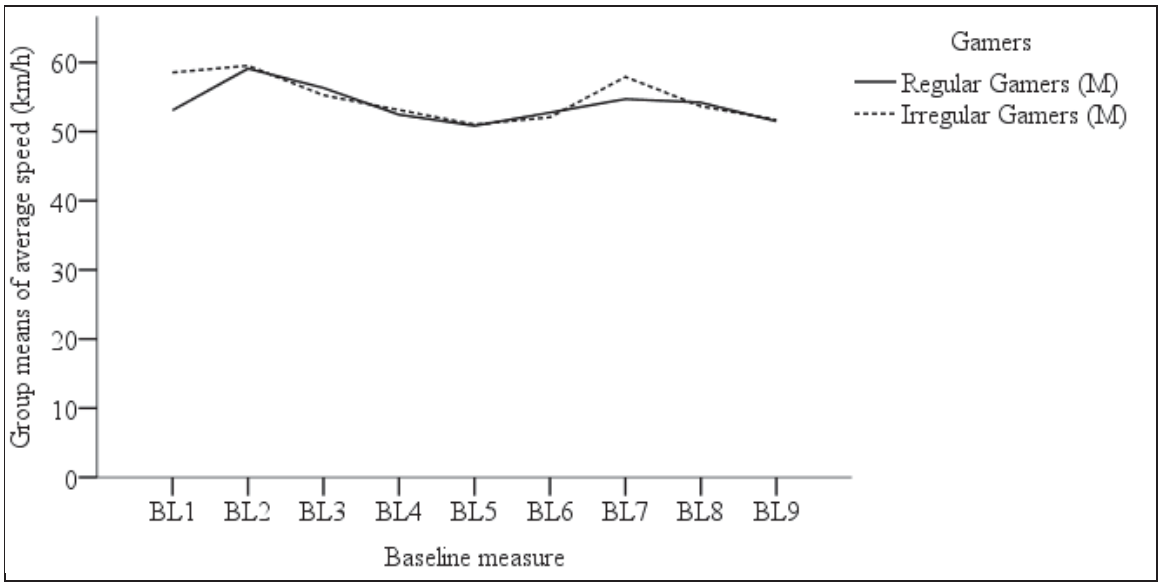

Figure 14. Average speed across the BL measures.

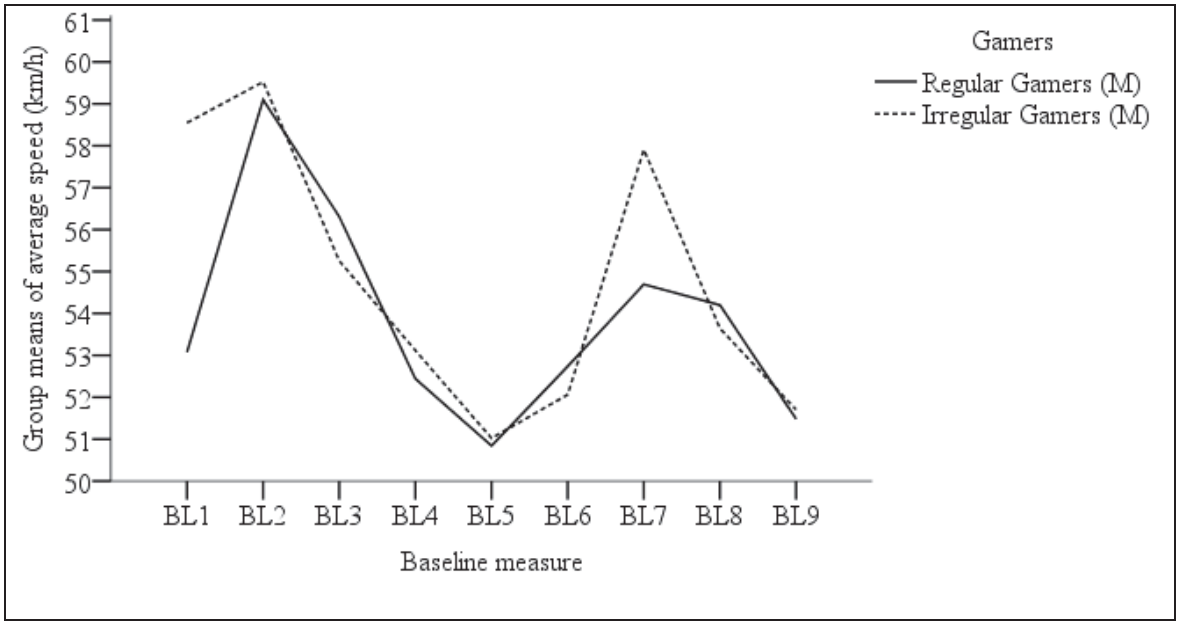

Figure 15. Magnified view of average speed across the BL measures.

Table 7
Regular gamers' significant post-hoc pairwise comparisons for BL average speed measures

BL - Average speed km/h	**BL - Average speed km/h**	**Mean difference**	**p-level**
BL2 - 59.1 km/h	BL4 - 52.4 km/h	6.7 km/h	$p = 0.03$
	BL5 - 50.8 km/h	8.3 km/h	$p = 0.03$
	BL6 - 52.7 km/h	6.4 km/h	$p = 0.05$
	BL9 - 51.5 km/h	7.6 km/h	$p = 0.01$
BL5 - 50.8 km/h	BL8 - 54.2 km/h	3.4 km/h	$p = 0.02$

Table 8
Irregular gamers' significant post-hoc pairwise comparisons for BL average speed measures

BL - Average speed km/h	**BL - Average speed km/h**	**Mean difference**	**p-level**
BL1 - 58.5 km/h	BL4 - 53.1 km/h	5.4 km/h	$p = 0.05$
	BL5 - 51.0 km/h	7.5 km/h	$p = 0.01$
	BL6 - 52.1 km/h	6.5 km/h	$p = 0.02$
	BL9 - 51.7 km/h	6.8 km/h	$p = 0.01$
BL2 - 59.5 km/h	BL4 - 53.1 km/h	6.4 km/h	$p = 0.01$
	BL5 - 51.0 km/h	8.5 km/h	$p < 0.001$
	BL6 - 52.1 km/h	7.5 km/h	$p = 0.002$
	BL9 - 51.7 km/h	7.8 km/h	$p < 0.001$
BL4 - 53.1 km/h	BL7 - 57.9 km/h	4.8 km/h	$p = 0.02$
BL5 - 51.0 km/h	BL7 - 57.9 km/h	6.9 km/h	$p < 0.001$
	BL8 - 53.6 km/h	2.6 km/h	$p = 0.05$
BL6 - 52.1 km/h	BL7 - 57.9 km/h	5.8 km/h	$p = 0.02$
BL7 - 57.9 km/h	BL8 - 53.6 km/h	4.3 km/h	$p = 0.03$
	BL9 - 51.7 km/h	6.2 km/h	$p < 0.001$

Table 9
Descriptive statistics of regular and irregular gamers at each BL measure.

	Regular gamers			**Irregular gamers**		
Baseline	**Average speed**	**SD**	**SE**	**Average speed**	**SD**	**SE**
BL1	53.1 km/h	5.10	2.28	58.5 km/h	9.95	2.00
BL2	59.1 km/h	5.31	1.89	59.5 km/h	7.77	1.66
BL3	56.3 km/h	7.17	2.13	55.3 km/h	8.03	1.86
BL4	52.4 km/h	3.56	1.31	53.1 km/h	5.42	1.14
BL5	50.8 km/h	2.23	0.81	51.0 km/h	3.33	0.71
BL6	52.7 km/h	2.69	0.74	52.1 km/h	2.65	0.65
BL7	54.7 km/h	3.79	1.61	57.9 km/h	6.95	1.40
BL8	54.2 km/h	3.98	1.26	53.6 km/h	4.92	1.10
BL9	51.5 km/h	3.31	0.97	51.7 km/h	3.64	0.85

Speed variance. The speed variance across the nine BL measures was analyzed to determine whether the participants had consistent control of the UCDS's speed. The speed variance refers to the amount of speed dispersion around the average velocity (i.e. the squared standard deviation of the speed variable (Garber & Gadirajum 1981). Speed variance is associated with vehicle control of speed maintenance; lower speed variance would indicate better speed maintenance while a higher value for speed variance would indicate poor speed maintenance.

A G-G corrected RM ANOVA analysis determined that between-subjects effects were not significant; regular gamers (M = 3.9 km/h, SE = 0.68) did not significantly differ from irregular gamers (M = 4.7 km/h, SE = 0.60) on speed variance ($F(1, 28) = 0.82$, $p = 0.37$). Similarly, the interaction effects of gamer type by BL measure were not significant ($F(2, 63) = 0.82$, $p = 0.46$).

Within-subjects main effect of BL measure were found to be significant ($F(2, 63) = 19.55$, $p < 0.001$), which indicated that speed variance of participant groups varied significantly between the BL measures. Figure 14 shows the pattern of speed variance

across BL measures and Table 10 lists the descriptive statistics for each gamer group. The significant ($p < 0.05$) post-hoc tests with a Bonferroni correction for regular and irregular gamers are listed in Table 11. All significant within-subject differences occurred between BL2 and another BL measure. This difference is likely due to the placement of BL2 after the participants' first encounter of a roadway that transitioned from a 70 km/hour zone to a 50 km/hour zone. While the data collection points in the drive were located 400 meters after the speed transition, the greater mean speed variance for both gamer groups might be indicative of the participants' adaptation to the UCDS in terms of braking and decelerating to meet the posted speed limit.

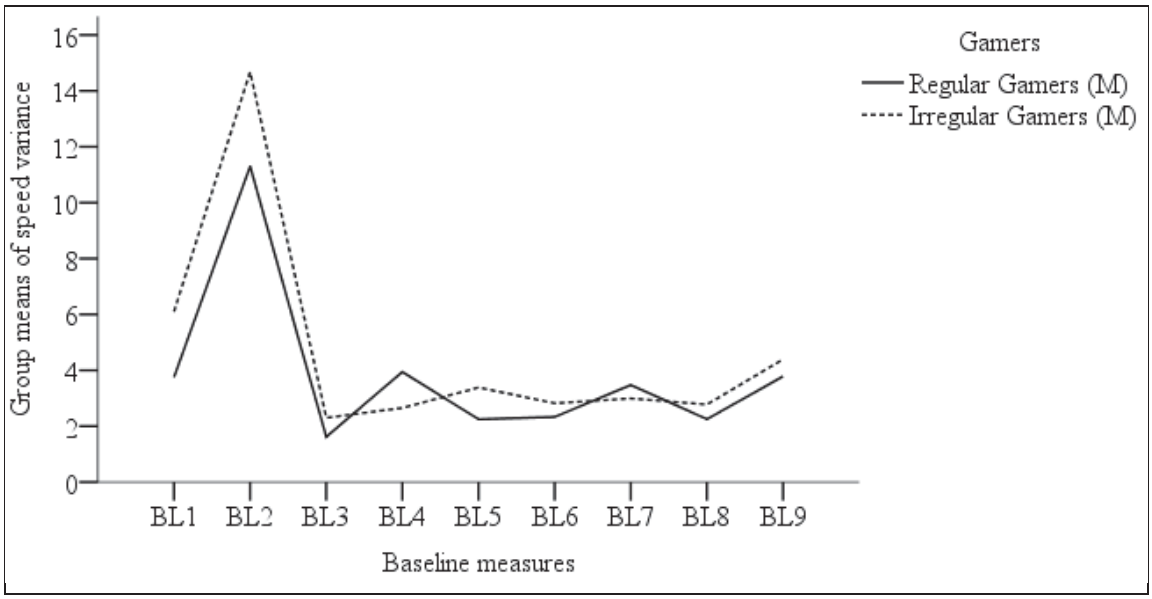

Figure 15 .Group means of speed variance at each BL measure.

Table 10
Descriptive statistics of speed variance for regular and irregular gamers.

	Regular gamers			**Irregular gamers**		
Baseline measure	**Mean speed variance**	**SD**	**SE**	**Mean speed variance**	**SD**	**SE**
BL1	3.8 km/h	6.56	1.60	6.1 km/h	5.12	1.40
BL2	11.3 km/h	6.50	2.84	14.7 km/h	12.3	2.48
BL3	1.6 km/h	1.41	0.47	2.3 km/h	1.85	0.41
BL4	3.9 km/h	4.52	0.98	2.7 km/h	2.52	0.85
BL5	2.2 km/h	1.88	0.72	3.4 km/h	3.00	0.63
BL6	2.3 km/h	1.60	0.52	2.8 km/h	2.03	0.45
BL7	3.5 km/h	4.21	0.92	3.0 km/h	2.44	0.80
BL8	2.6 km/h	1.94	0.62	2.8 km/h	2.43	0.54
BL9	3.8 km/h	3.19	1.04	4.4 km/h	4.10	0.91

Table 11
Regular gamers' significant post-hoc pairwise comparisons of speed variance.

Regular gamers			
BL / Mean speed	**BL / Mean speed**	**Mean difference**	***p*-level**
BL2 - 11.3 km/h	BL5 - 2.2 km/h	9.1 km/h	$p = 0.04$
Irregular gamers			
BL / Mean speed	**BL / Mean speed**	**Mean difference**	***p*-level**
BL2 - 14.7 km/h	BL3- 2.3 km/h	12.4 km/h	$p = 0.001$
	BL4 - 2.7 km/h	12.0 km/h	$p = 0.002$
	BL5 - 3.4 km/h	11.3 km/h	$p = 0.001$
	BL6 - 2.8 km/h	11.9 km/h	$p = 0.001$
	BL7 - 3.0 km/h	11.7 km/h	$p = 0.004$
	BL8 - 2.8 km/h	11.9 km/h	$p = 0.002$
	BL9 - 4.4 km/h	10.3 km/h	$p = 0.005$

Standard deviation of lane position (SDLP). SDLP measures how well lane position is maintained in metres (i.e. lane keeping) (Milloy & Caird , 2011). Greater SDLP would be indicative of less vehicular control. Results from a 2(gamer type) by 9(BL – SDLP) RM ANOVA (with SDLP as the within-subject variable) found that between-subjects effects of gamer type was significant ($F(1, 28) = 4.57$, $p = 0.042$). Overall, the regular gamers had lower SDLP (M = 0.09, SE = 0.01) which indicated they had greater steering control and lane maintenance in the UCDS than the irregular gamers (M = 0.11, SE = 0.004) (Figure 16).

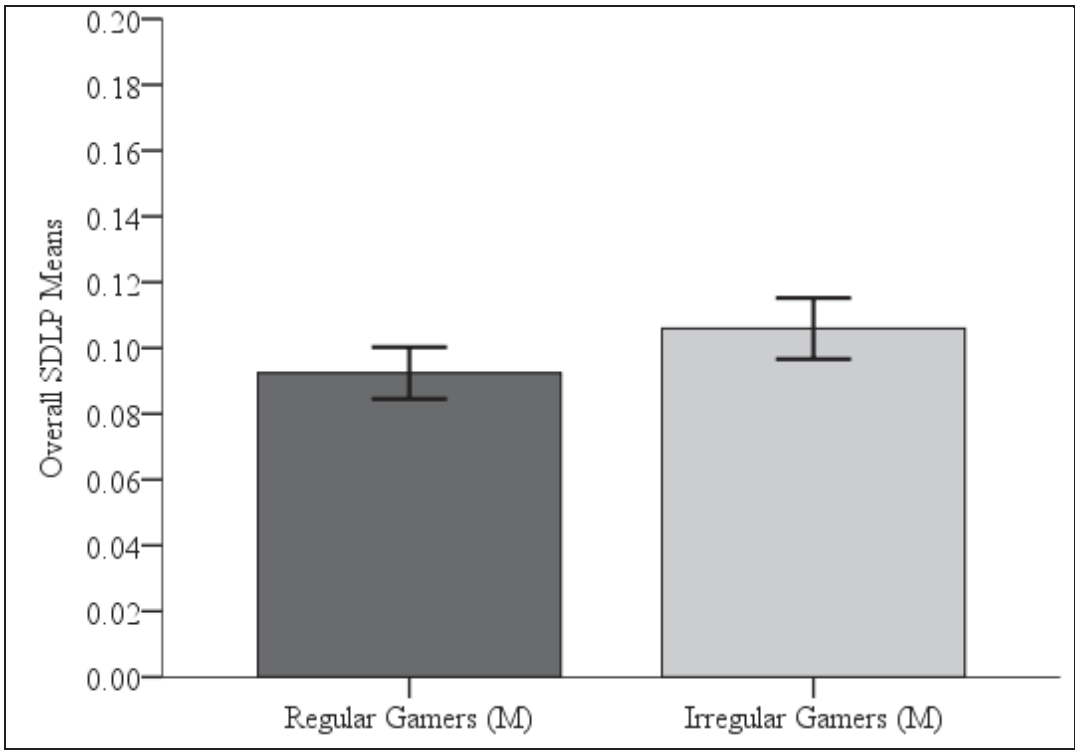

Figure 16. Overall SDLP means for regular and irregular gamers.

Within-subjects effect of SDLP across BL measures were also significant ($F(8, 28) = 3.30$, $p < 0.001$). Figure 17 shows the group SDLP means of each group at each BL measure and Table 12 provides the accompanying descriptive statistics. Regular gamers and irregular gamers both exhibited their peak SDLP during the first baseline

measure. This peak in the SDLP data might be indicative of the participant groups' unfamiliarity with handling the UCDS and subsequent adaptation as the driving scenarios progressed. However, post-hoc pairwise comparison tests revealed only one instance of a significant within-subject effect; the SDLP of irregular gamers between BL1 and BL9 was significant with a Bonferroni correction (p = 0.03). No significant interaction effects were found ($F(5, 143) = 0.01$, $p = 0.92$).

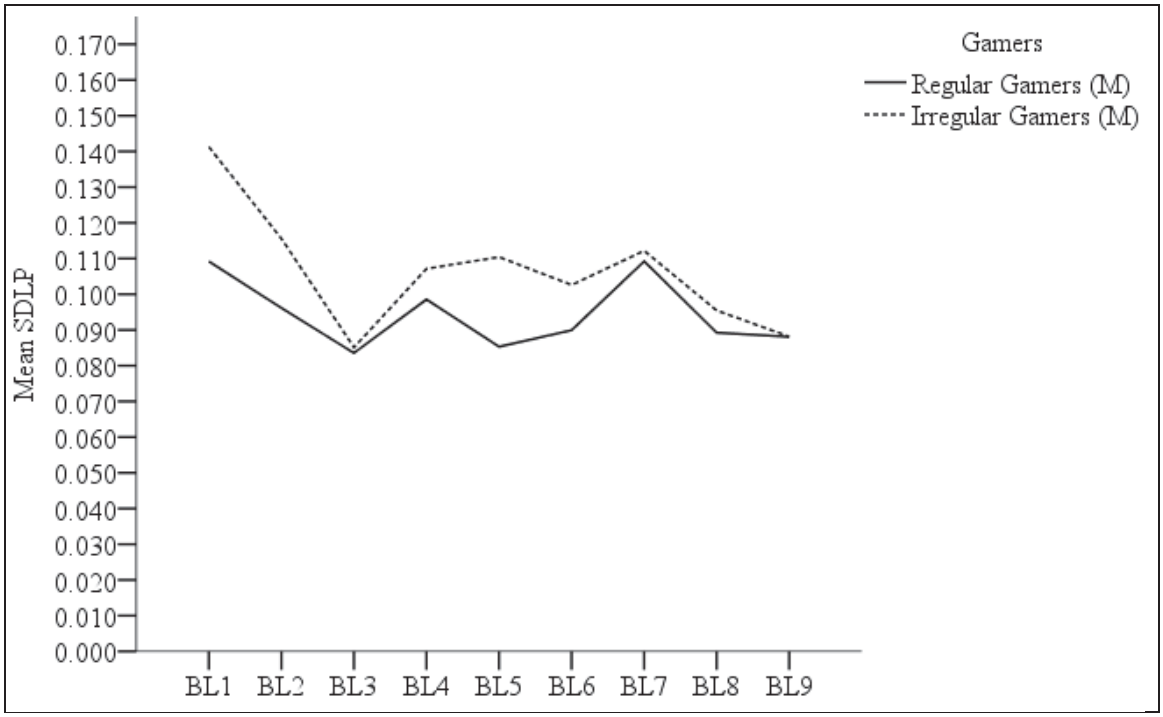

Figure 17. Mean SDLP at each BL measure.

Table 12
Descriptive statistics of SDLP for regular and irregular gamers.

Regular gamers				**Irregular gamers**			
	Mean SDLP	**SD**	**SE**		**Mean SDLP**	**SD**	**SE**
BL1	0.109	0.034	0.018	**BL1**	0.148	0.079	0.015
BL2	0.088	0.033	0.010	**BL2**	0.109	0.038	0.009
BL3	0.080	0.033	0.010	**BL3**	0.086	0.038	0.009
BL4	0.094	0.031	0.012	**BL4**	0.107	0.052	0.011
BL5	0.080	0.022	0.008	**BL5**	0.110	0.033	0.007
BL6	0.093	0.049	0.011	**BL6**	0.102	0.031	0.010
BL7	0.105	0.039	0.010	**BL7**	0.108	0.031	0.008
BL8	0.093	0.029	0.011	**BL8**	0.098	0.045	0.009
BL9	0.090	0.029	0.008	**BL9**	0.086	0.031	0.007

Reduce speed event (RSE).

Measures of deceleration and adherence to a reduced change of speed limit, were collected in driving scenarios 1 and 2 and analyzed using a G-G corrected 2[gamer type] x 4[RSE] RM ANOVA with the RSE variable (deceleration or speed at the new posted speed limit) as the within-subjects variable. Participants were presented with a 90 km/h to 70 km/h speed transition from a freeway to an urban roadway twice within each driving scenario (four times total). Deceleration rates and speed at the new posted speed sign were the variables analyzed at each RSE. The between-subject effects were the primary interest, but the within-subject and interaction effects were also analyzed. Two cases are missing from the analysis because of data collection error in which the UCDS stopped collecting data partway through the driving scenario.

Deceleration profiles. Deceleration profiles were calculated for each participant over a 150 m stretch of straight roadway from immediately perpendicular to a sign that read “Reduced Speed Ahead” up until the participants reached the new 70 km/h posted

speed limit. There were no significant between-subjects effects; the regular gamers (M = -1.47 km/h^2, SE = 0.13) and irregular gamers (M = -1.63 km/h^2, SE = 0.11) did not have significantly different deceleration rates ($F(1, 27) = 0.85$, $p = 0.37$). There were also no interaction effects ($F(3, 81) = 2.13$, $p = 0.10$). Figure 18 demonstrates the observed pattern of deceleration rates across RSE measures and is accompanied by Table 13 which lists the associated descriptive statistics.

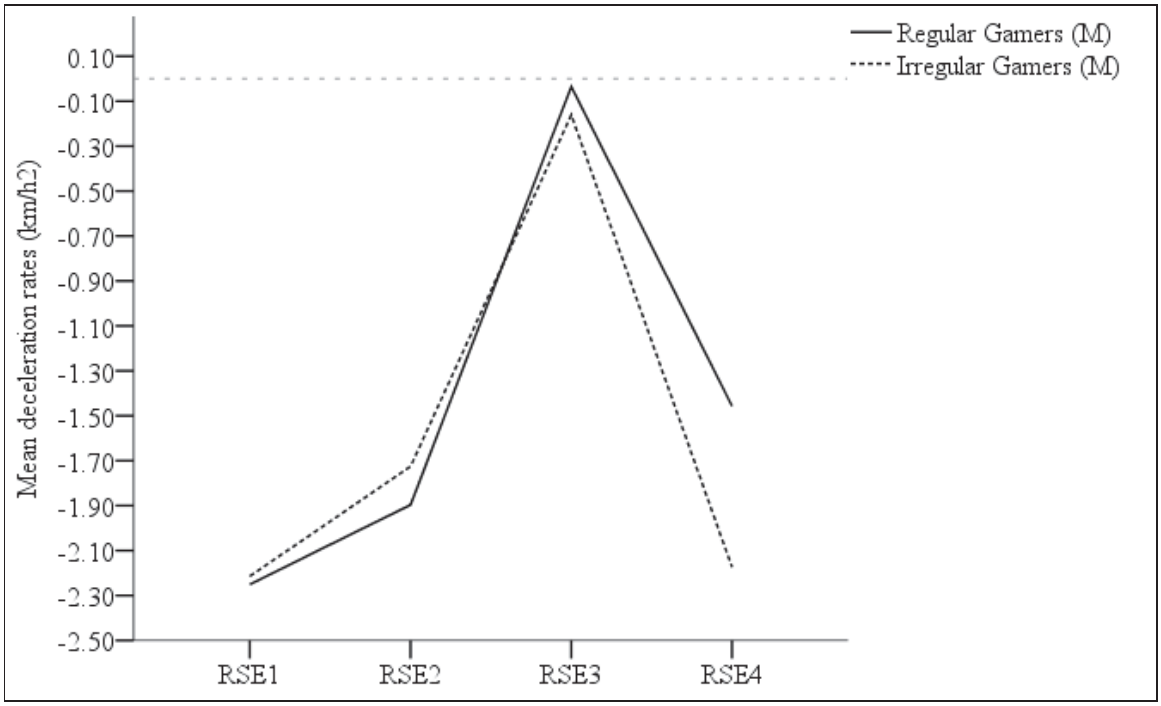

Figure 18. Mean deceleration rates across RSE for regular and irregular gamers.

Table 13
Descriptive statistics for deceleration rates across the RSE for regular and irregular gamers.

Regular gamers				**Irregular gamers**			
RSE	**Mean deceleration**	**SD**	**SE**	**RSE**	**Mean deceleration**	**SD**	**SE**
RSE1	-2.3 km/h^2	0.82	0.33	**RSE1**	-2.2 km/h^2	1.33	0.28
RSE2	-2.0 km/h^2	0.80	0.19	**RSE2**	-1.7 km/h^2	0.53	0.16
RSE3	-0.04 km/h^2	0.01	0.13	**RSE3**	-0.28 km/h^2	0.59	0.11
RSE4	-1.6 km/h^2	0.89	0.28	**RSE4**	-2.4 km/h^2	0.89	0.24

A within–subjects main effect of deceleration across RSE (deceleration) was significant ($F(1, 27) = 8.87$, $p < 0.001$). Figure 18 shows the group means for deceleration rates across the four RSE. Post-hoc pairwise comparison tests revealed that both participant groups experienced significant ($p < 0.05$ with a Bonferroni correction) within-subject effects between RSE3 with all other instances of the RSE (Table 14).The mean deceleration rates appeared to be relatively consistent for the RSE1, RSE2 and RSE4 , however, at RSE3 participants exhibited the least deceleration and in some cases were actually accelerating at as they approached the new posted speed sign. Possibilities for this difference will be addressed in the discussion.

Table 14
Significant post-hoc pairwise comparisons of deceleration rates at the RSE.

Gamer type	**RSE - deceleration**	**RSE - deceleration**	**Mean difference**	**p-level**
Regular gamers	RSE3 - ¯0.04 km/h^2	RSE1 - ¯2.3 km/h^2	2.3 km/h^2	$p < 0.001$
		RSE2 - ¯2.0 km/h^2	1.9 km/h^2	$p < 0.001$
		RSE4 - ¯1.6 km/h^2	1.5 km/h^2	$p < 0.001$
Irregular gamers	RSE3 - ¯0.18 km/h^2	RSE1 - ¯2.2 km/h^2	2.1 km/h^2	$p < 0.001$
		RSE2 - ¯1.7 km/h^2	1.5 km/h^2	$p < 0.001$
		RSE4 - ¯2.4 km/h^2	2.2 km/h^2	$p < 0.001$

Speed at the reduced speed limit sign. Each participant's speed at the new posted speed limit was collected to determine whether there were group differences in adhering to the new speed limit across RSE. Figure 19 graphs group patterns across RSE and Table 15 records the descriptive statistics for speed across RSE. The speed at the new speed limit was analyzed with a G-G corrected RM ANOVA. There were no significant between-subjects effects at the new posted speed sign (70 km/h) (regular gamers: M = 75.6 km/h, SE = 1.85; irregular gamers: M = 75.6 km/h, SE = 1.66) ($F(1,27) = 0.00$, p = 1.00). Similarly, within-subject effect were not significant ($F(3, 60) = 0.31$, $p = 0.76$). A

marginally significant interaction (gamer type by RSE-speed at the new posted speed limit) was present ($F(23, 60 = 2.23, p = 0.06)$). Both gamer groups saw a trend at RSE4 in which regular gamers exhibited an increase of mean group speed at the 70 km/h posted speed sign (M = 78.8 km/h, SE = 2.34) compared to irregular gamers (M = 74.0 km/h, SE = 2.71). It is uncertain why the regular gamers would be showing declines in adhering to the posted speed limits at this point in the experiment, however, the large amount of variance would likely eliminate any substantive differences.

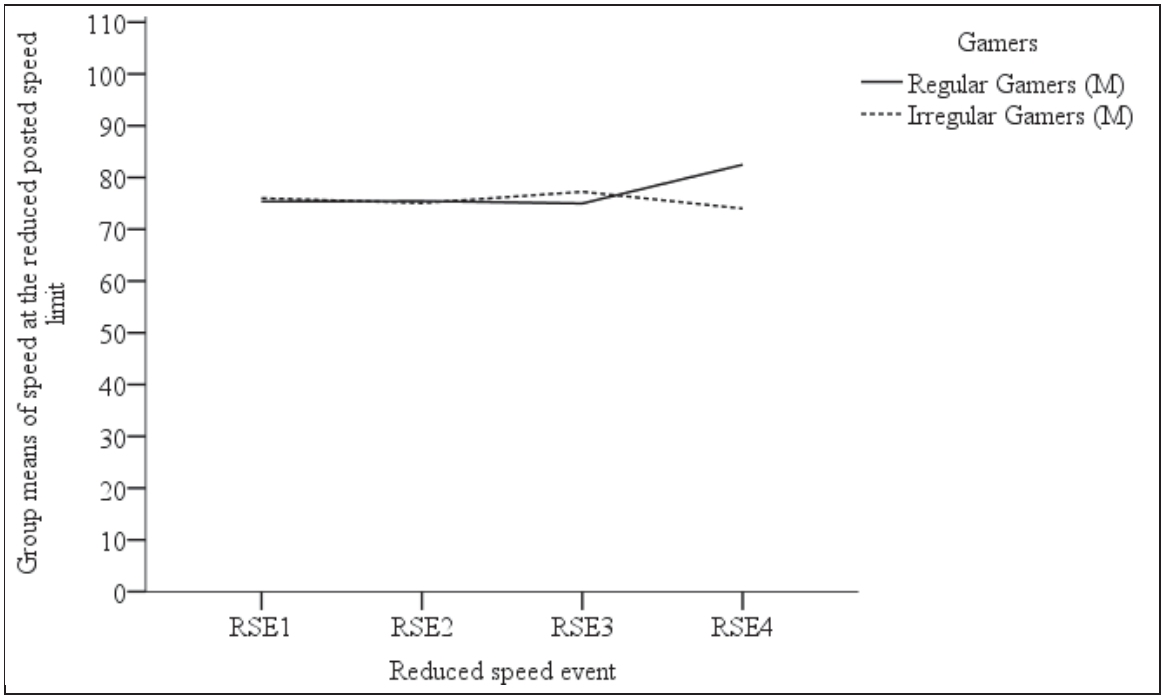

Figure 19. Mean speed (km/h) at a new posted speed limit (70 km/h).

Table 15
Descriptive statistics for regular and irregular gamers' speed at the new posted speed limit.

Regular gamers				**Irregular gamers**			
RSE	**Mean speed**	**SD**	**SE**	**RSE**	**Mean speed**	**SD**	**SE**
RSE1	75.4 km/h	5.62	1.89	**RSE1**	76.0 km/h	7.13	1.59
RSE2	75.4 km/h	5.52	2.08	**RSE2**	75.1 km/h	8.18	1.75
RSE3	75.0 km/h	7.37	2.67	**RSE3**	77.3 km/h	10.36	2.25
RSE4	82.5 km/h	15.08	3.23	**RSE4**	74.0 km/h	7.40	2.71

Driving events

Forward stepwise-logistic regression analysis (stepwise-LR). Several driving events were analyzed using a forward stepwise-LR with five predictor variables (gamer type, sensation seeking scores, IPIP risk-taking scores, driver confidence scores and length of licensure described in Table 16)**.** Binary outcomes (high-risk/not high-risk outcomes) were defined for the late yellow light, left turn across traffic, tailgating and pull-out car events. The primary focus of the stepwise-LR analysis was to determine whether gamer type accounted for a significant amount of variance and was predictive of high-risk driving outcomes above and beyond the other predictor variables known to be related to high-risk driving behaviour.

Table 16
Description of the variables entered into the stepwise logistic analyses.

Variable	**Description**
Gamer type	Gamer type is comprised of two groups: regular gamers and irregular gamers and is the primary variable of interest (see Table 1 for a more detailed explanation). This study aims to determine whether group membership to regular or irregular gamer type is predictive of high-risk behaviour in driving events.
Sensation Seeking Scale score	Sensation seeking purports to measure an individual's propensity to seek novel sensations and experiences in the face of any associated risks (Zuckerman, 1979). Higher SSS scores have been associated with riskier driving behaviour (Jonah, 1990), particularly speeding, street racing and illegal passing (Arnett, 1996).
IPIP-Risk-Taking score	International Personality Item Pool sub-scale for risk (the IPIP is a measure of NEO-PI-R constructs available for use in the public domain). The IPIP scale for risk-taking is based on the revised Jackson Personality Inventory (JPI-R) for risk-taking. Higher scores are indicative of a an individual who enjoys taking a chance and willing to expose themselves to situations with uncertain outcomes (even with risk of personal injury) and is unconcerned with danger (Goldberg, Johnson, Eber, Hogan, Ashton, Cloninger & Gough, 2006)).
Driver Confidence Questionnaire scores	Driver Confidence Questionnaire (CQ) requires participants to rate their subjective confidence of their ability in regard to different driving situations. It's been suggested that over-inflated scores on driver confidence might indicate the driver's inability to accurately assess their skill and ability to assess risk associated with driving events (Brown and Groeger, 1988).
Length of licensure	Length of licensure referred to each participant's total licensure in months from their learner's license up until their participation in the research scenario and was used as a measure of driver experience. Driver skill and ability to avoid high-risk driving events would be expected to improve with driver experience.

A one-way ANOVA was run on each predictor variable to determine whether any existing group differences were present. This was also done to determine whether collinearity might be a concern during the logistic regression analysis. While not significant, IPIP-Risk-Taking scores (regular gamers: M = 29.92, SD =5.37; irregular gamers: M = 33. 17, SD =4.59; F(1,29) = 3. 27, p = 0.08) and Driver Confidence scores (regular gamers: M = 57. 85, SD =4.56; irregular gamers: M = 60.44, SD =3. 78; F(1,29) = 3. 00, p = 0.09) were marginally significant (Figure 20 and Figure 21 respectively). Sensation seeking scores (regular gamers: M = 17.77,
SD =1.30 ; irregular gamers: M = 18.06, SD =3. 06; F(1,29) = 0.10, p = 0.75) and length of licensure (regular gamers: M = 41.92, SD =15.89; irregular gamers: M = 55.22, SD = 29.50; F(1,29) = 2.17, p = 0.15) were not significant.

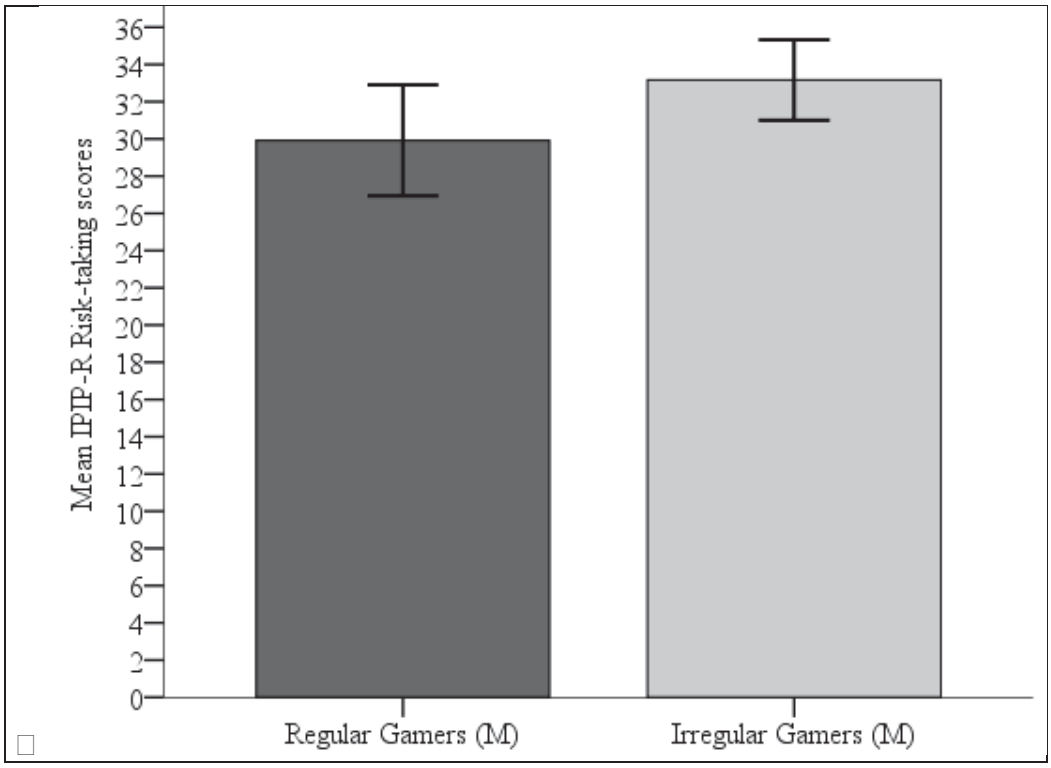

Figure 20. Group means for IPIP-Risk-Taking scores (Error Bars: +/- 2 SE).

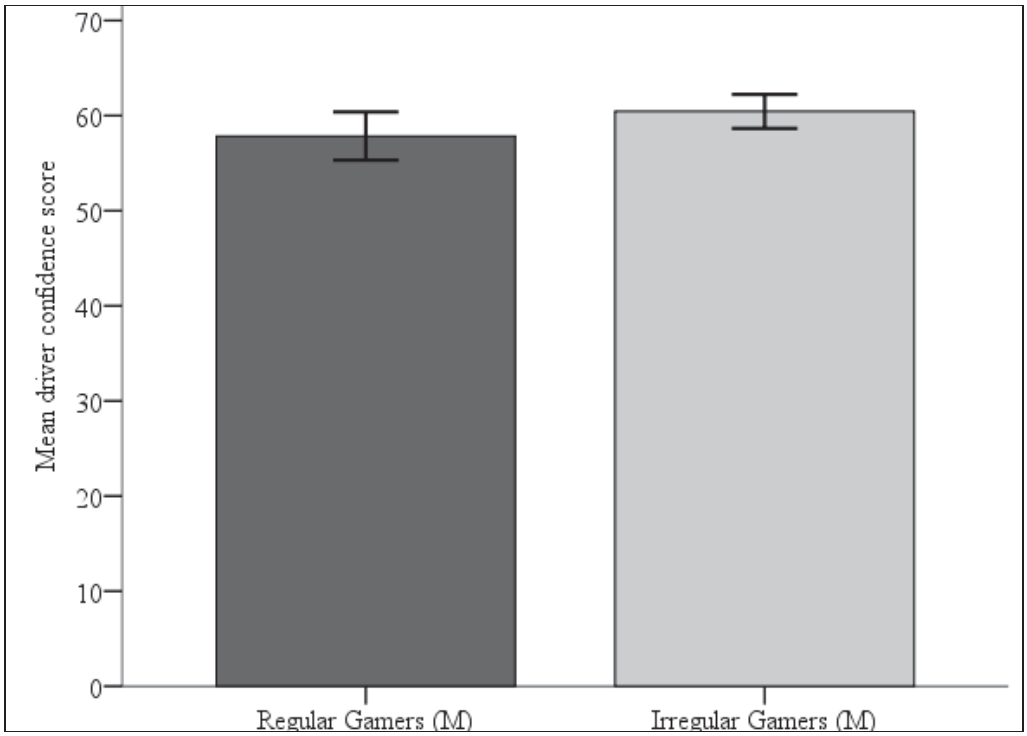

Figure 21. Group means for driver confidence scores (Error Bars: +/- 2 SE).

Late yellow light event

Four outcome variables were analyzed for the late yellow light event; anticipation, indecision, stop/go decision and intersection clearance (Table 17 provides a description of each outcome variable). The participants' behaviour was examined as they approached the green traffic light, and after the light would turn yellow (2.21 seconds from the intersection stopline).

Table 17
Description outcome variables for the late yellow light event.

Outcome variable	**Description**
Anticipation	Anticipatory behaviour included a change in braking, accelerating or "foot waggle" (hovering the foot between the brake and accelerator intermittently) once the "stale" green traffic light was visible on screen (within 300 metres of the stop-line) and up until the traffic light turned yellow.
Indecision	Indecisive behaviours were observed once the traffic light turned yellow and the participants had to make a decision whether to stop or proceed through the intersection. Indecisive behaviour included a combination of rapid braking or accelerating or rapid "foot waggle" before ultimately choosing to proceed or stop at the intersection.
Stop/go decision	Stop/go decision was simply whether the participant came to a complete stop at the yellow light or proceeded through the intersection. Stopping was considered a low-risk outcome while proceeding through the intersection was considered a high-risk outcome.
Intersection clearance	Intersection clearance refers to whether the participants who proceeded through the yellow light were able to clear the intersection before the light turned red. Intersection clearance required the back bumper of the UCDS to have exited the intersection before the light turned red.

Anticipation. Few participants exhibited anticipatory behaviour when approaching the "stale" green light; only 4 participants in scenario 1 and 3 participants in scenario 2 exhibited anticipatory behaviour. A logistic regression analysis was deemed unfeasible given that less than 15% of the participants showed any sort of anticipatory behaviour. The outcome variable's lack of variation was not expected as regular gamers were hypothesized to exhibit greater anticipatory behaviour than irregular gamers.

Indecision. Similar to the anticipation outcome, few participants exhibited indecisive driving behaviour once the traffic light turned yellow. A logistic regression analysis was not feasible since only 5 participants in scenario 1 and 3 participants in scenario 2 exhibited indecisive behaviour. Regular gamers were hypothesized to 'commit' more to an action than irregular gamers, however these results are inconclusive.

Stop/go decision. Only six participants in scenario 1 and five participants in scenario 2 stopped at the intersection when the traffic light turned yellow. While not optimal, a logistic regression analysis was run for scenario 1's stop/go (low-risk/high-risk) event since the number of participants who stopped accounted for nearly 20% of the entire sample (19.35%). None of the predictor variables (Table 16) were found to significantly improve the classification model (Table 18). Regular gamers were hypothesized to run the yellow light more often, but the results suggest that both groups had a propensity to run yellow lights. However, when considering stop/go proportions of each group, a greater number of irregular gamers did stop for the yellow light (four in scenario 1 (Figure 22) and five in scenario 2 (Figure 23)).

Table 18
The significance of each predictor variable in scenario 1 for stop/go behaviour.

Predictor Variable	**Significance level Scenario 1**
Gamer type	$p = 0.63$
Sensation seeking scale scores	$p = 0.62$
IPIP-R risk-taking scores	$p = 0.85$
Driver confidence scores	$p = 0.13$
Length of licensure	$p = 0.76$

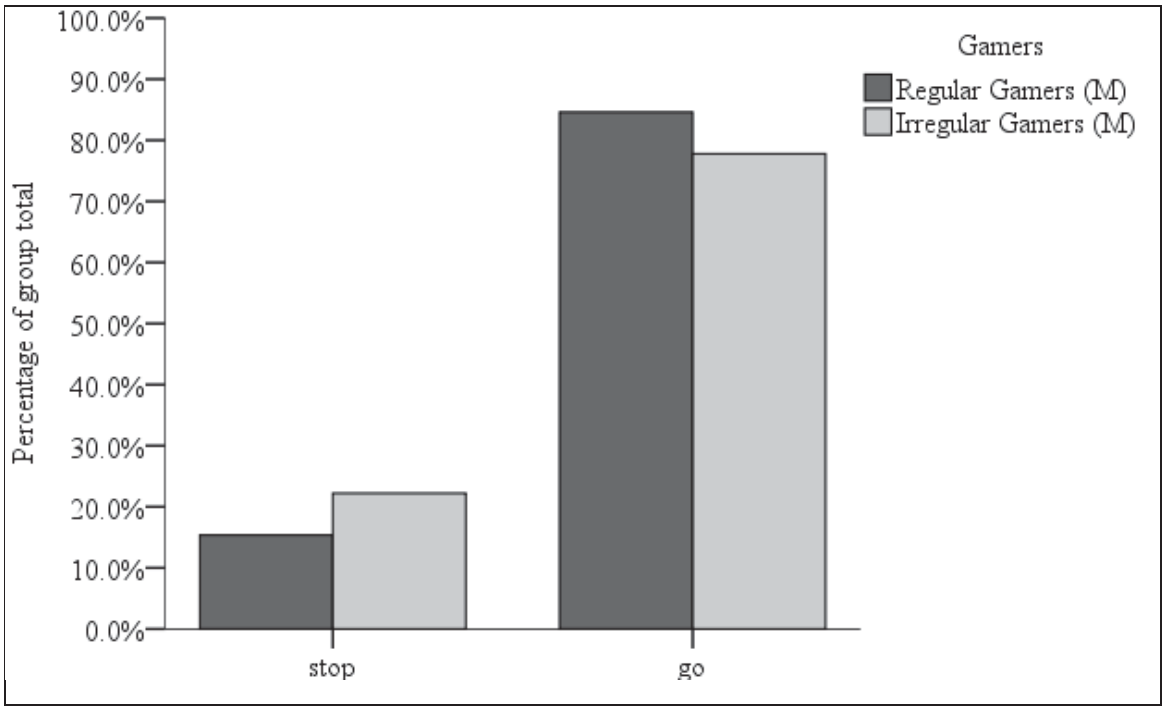

Figure 22. Scenario 1 group percentages of stop/go behaviour at the late yellow light.

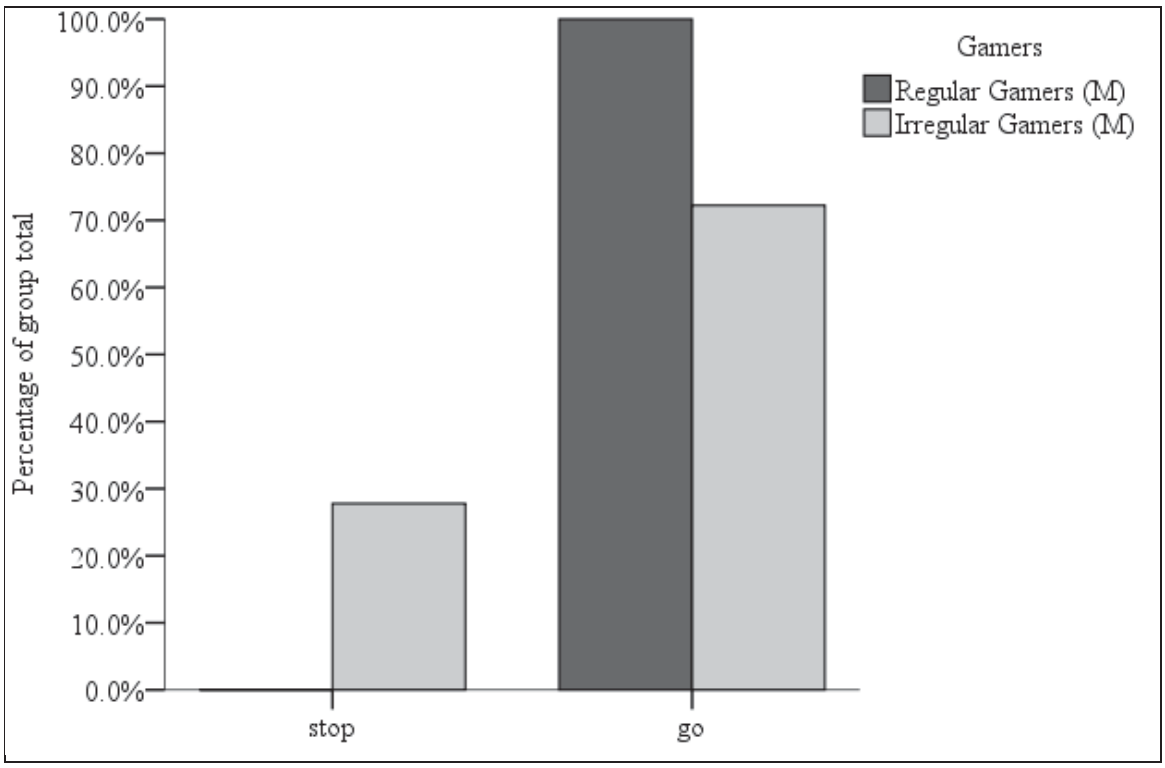

Figure 23. Scenario 2 group percentages of stop/go behaviour at the late yellow light.

Intersection Clearance. All drivers who ran the yellow light were able to clear the intersection before the light turned red. There were no cases where the participant failed to clear the intersection.

Left turn event

Completed left turn across traffic or waited. In each driving scenario the participants were presented with a left turn at a controlled intersection. The event would start once the participant stopped at a red light intersection and the light would then turn green. On-coming traffic in the opposite lane would proceed through the intersection with specific time gaps (2.5 s – 6.5 s) programmed between each vehicle. The gaps were measured from the leading vehicle's back bumper and following vehicle's front bumper. For the logistic regression, the outcome variable was considered whether the participant waited for all oncoming traffic to pass through the intersection (low-risk outcome) or complete the left turn across the flow of traffic (high-risk outcome).

The predictor variables (Table 16) did not significantly improve the prediction of left turn behaviour outcomes (waited or turned across traffic) in either scenario 1 or scenario 2 (Table 19). In both driving scenarios, six participants waited for all traffic to clear the intersection before completing the left turn, while 25 participants crossed traffic to complete the left turn. Figure 24 and Figure 25 show the proportion of actual time gap acceptance for participants in scenario 1 and scenario 2.

The lack of significant findings suggests that the five predictor variables (Table 16) were a poor fit for the outcome variable (waited or turned across traffic). Gamer type was particularly poor and did not validate the hypothesis that regular gamers were more likely to complete a cross-traffic left turn than irregular gamers. The lack of findings for

the IPIP-Risk scores was also interesting in that higher self-rated scores of risk-taking would be expected to correlate with incidences of cross-traffic left turns.

Table 19
The significance level of each predictor variable for turning across traffic of waiting behaviour.

Predictor Variable	**Significance level**	
	Scenario 1	**Scenario 2**
Gamer type	$p = 0.63$	$p = 0.63$
Sensation seeking scale scores	$p = 0.11$	$p = 0.31$
IPIP-R risk-taking scores	$p = 0.99$	$p = 0.92$
Driver confidence scores	$p = 0.23$	$p = 0.93$
Length of licensure	$p = 0.32$	$p = 0.18$

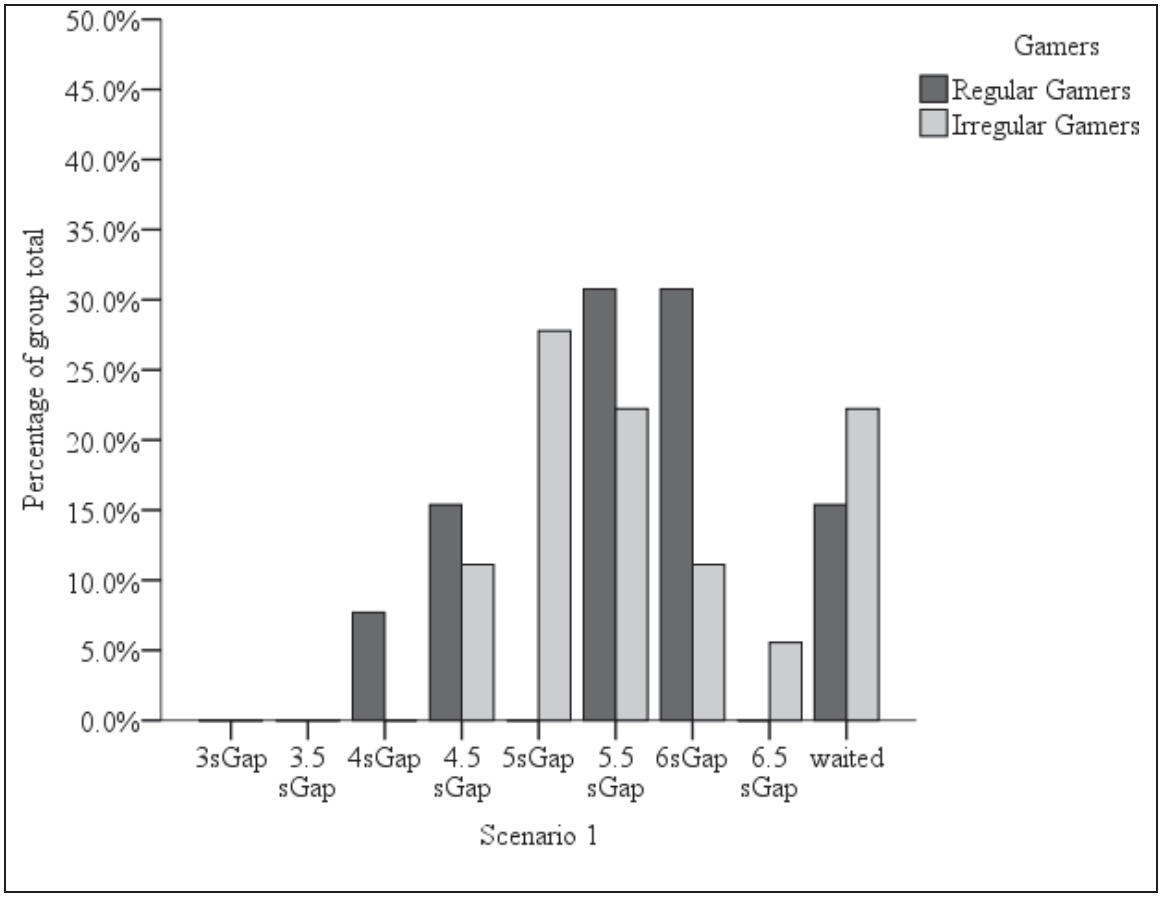

Figure 24. Scenario 1 group percentages of gap acceptance choice.

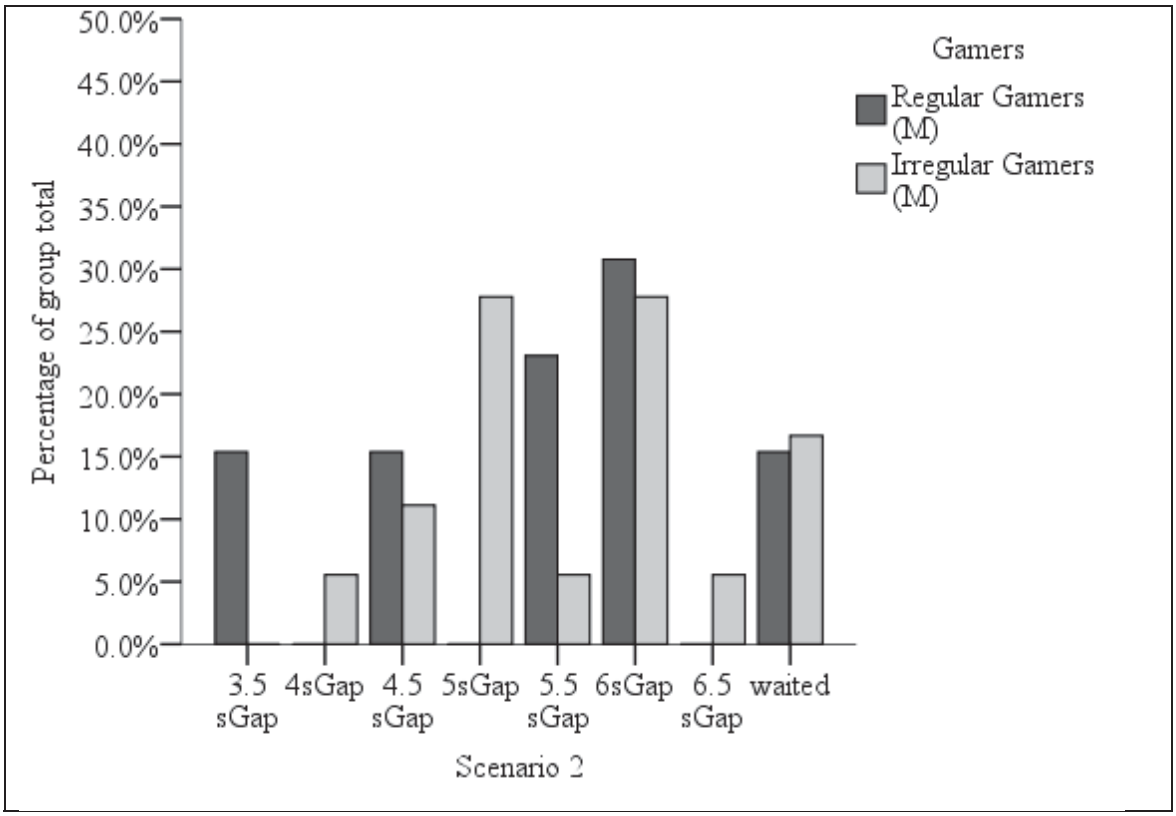

Figure 25. Scenario 2 group percentages of gap acceptance choice

Repeated-measures of gap acceptance. The data was also analyzed using a 2 [gamer type] x 2 [scenario – gap acceptance in scenario 1 and scenario 2] RM ANOVA to determine whether participants' gap acceptance differed between scenarios. The experimental design crossed gamer type as the between-subjects factor and scenario as the within-subjects factor. No significant between-subjects effects were found between regular gamers (M = 5.52, SE = 0.25) and irregular gamers (M = 5.65, SE = 0.21) on gap acceptance, $F(1,29) = 0.17$, $p = 0.68$. These results suggest that the regular gamers did not have a significantly higher risk for gap acceptance than the irregular gamers. Similarly, there was no significant within-subjects effect of scenario, $F(1,29) = 1.34$, $p = 0.26$, or gamer type by scenario interaction, $F(1,29) = 0.21$, $p = 0.65$. This suggests that

the participants did not change their gap acceptance significantly between the driving scenarios.

Collisions during the left turn event. While some participants crossed traffic at high-risk time gaps, none of the participants had a collision with oncoming traffic.

Tailgating event

In the first driving event the participants were presented with a slow moving lead vehicle that travelled at 35 km/h, which was 15 km below the speed limit. How participants interacted with this slow moving car was examined to determine whether the regular gamers followed the lead car with an unsafe headway time compared to irregular gamers. Unsafe headway time was calculated as the mean time that participants maintained between the front bumper of the simulator and the rear bumper of the lead vehicle. Table 20 explains how unsafe and safe headway times were categorized.

Table 20
Description of unsafe and safe average headway times.

Outcome variable	**Description**
Unsafe Headway time	If the participant maintained an average headway time that was less than 2 seconds , that participant's headway time was coded as "unsafe" (coded 0 in the analysis).
Safe Headway time	If the participant maintained an average headway time that was 2 or more seconds , that participant's headway time was coded as "safe" (coded 1 in the analysis).

Overall, fifteen participants were categorized as maintaining an unsafe headway time and fifteen participants were categorized as maintaining a safe headway time (Figure 26). One case was missing from the analysis because the participant entered the oncoming traffic lane and passed the lead vehicle. The predictor variables entered into the stepwise logistic analysis performed so poorly, that none were entered into the classification model (Table 21). This result did not support the hypothesis that gamer

type, specifically regular gamers would be significantly related to unsafe headway times. Further, it was surprising that none of the other predictor variables, particularly risk-taking scores, showed a trend towards unsafe headway time.

Table 21
The significance level of variance accounted for by each predictor variable.

Predictor Variable	**Significance level Scenario 1**
Gamer type	$p = 0.46$
Sensation seeking scale scores	$p = 0.61$
IPIP-R risk-taking scores	$p = 0.69$
Driver confidence scores	$p = 0.90$
Length of licensure	$p = 0.39$

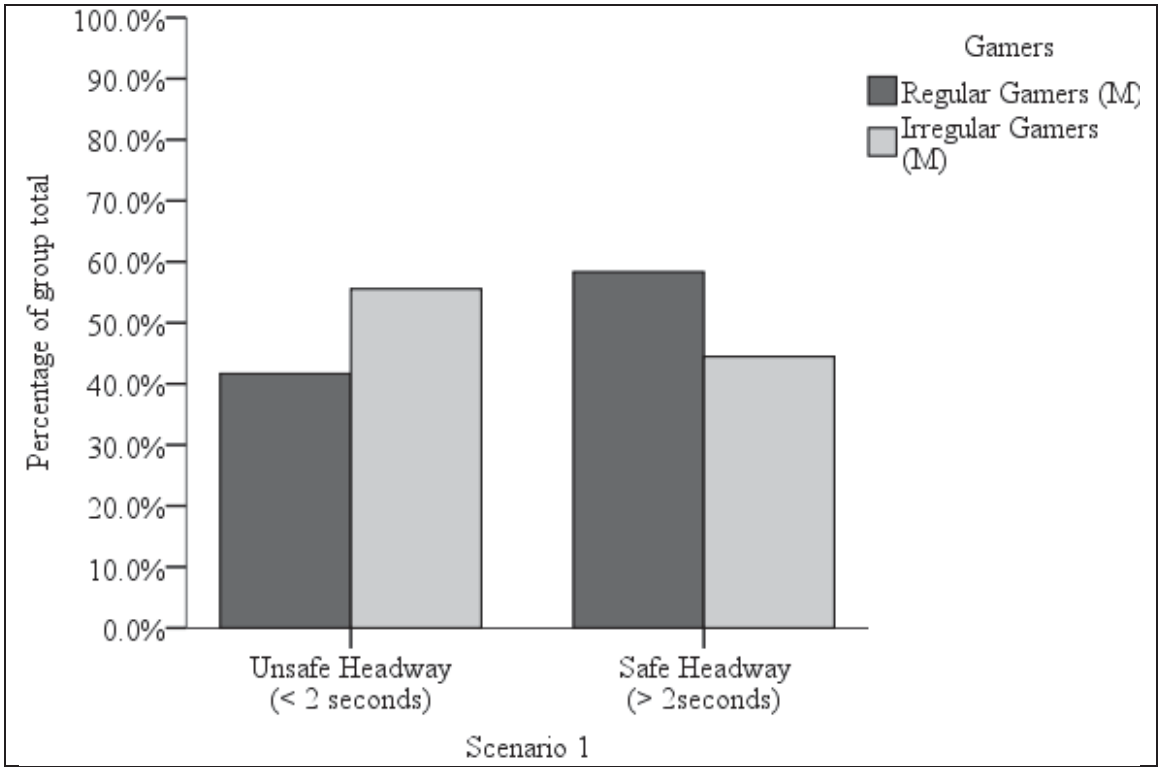

Figure 26. Group percentages for unsafe and safe headway following times averages.

Pull-out car event

Rear-end collision with the pull-out car. In the second driving scenario, a parked car would suddenly and unexpectedly enter the roadway directly in the path of the participant. The participants had to respond to avoid a rear-end collision with the pull-out car. For the stepwise-LR, the variable outcomes were based on whether the participant successfully avoided a collision or if the participant rear-ended/collided with the pull-out car. Overall, there 17 observations collisions with the pull-out car and were 14 instances of collision avoidance.

The predictor variables (Table 16) entered into the stepwise-LR were not significant and therefore not entered into the classification (Table 22). The lack of significant results indicated that the main variable of interest, gamer type, was not predictive of collision avoidance (Figure 27 shows the percentage of participants that had a collision in each gamer group). The hypothesis suggested that regular gamers would have faster reaction times and ability to maneouver the UCDS to avoid a collision. While not significant, length of licensure (p = 0.14) and scores on the SSS (p = 0.14) were towards significance. Length of licensure indicated a trend that participants with more driving experience tended to be better at avoiding a collision with the pull-out car (Figure 28). The trend with SSS scores was not expected as higher scores on the SSS tended to be associated with successful collision avoidance, while lower SSS scores tended to be associated with collisions with the pull-out car (Figure 29).

Table 22
The significance level of each predictor variable for collision outcome.

Predictor Variable	**Significance level Scenario 2**
Gamer type	$p = 0.52$
Sensation seeking scale scores	$p = 0.14$
IPIP-R risk-taking scores	$p = 0.63$
Driver confidence scores	$p = 0.73$
Length of licensure	$p = 0.14$

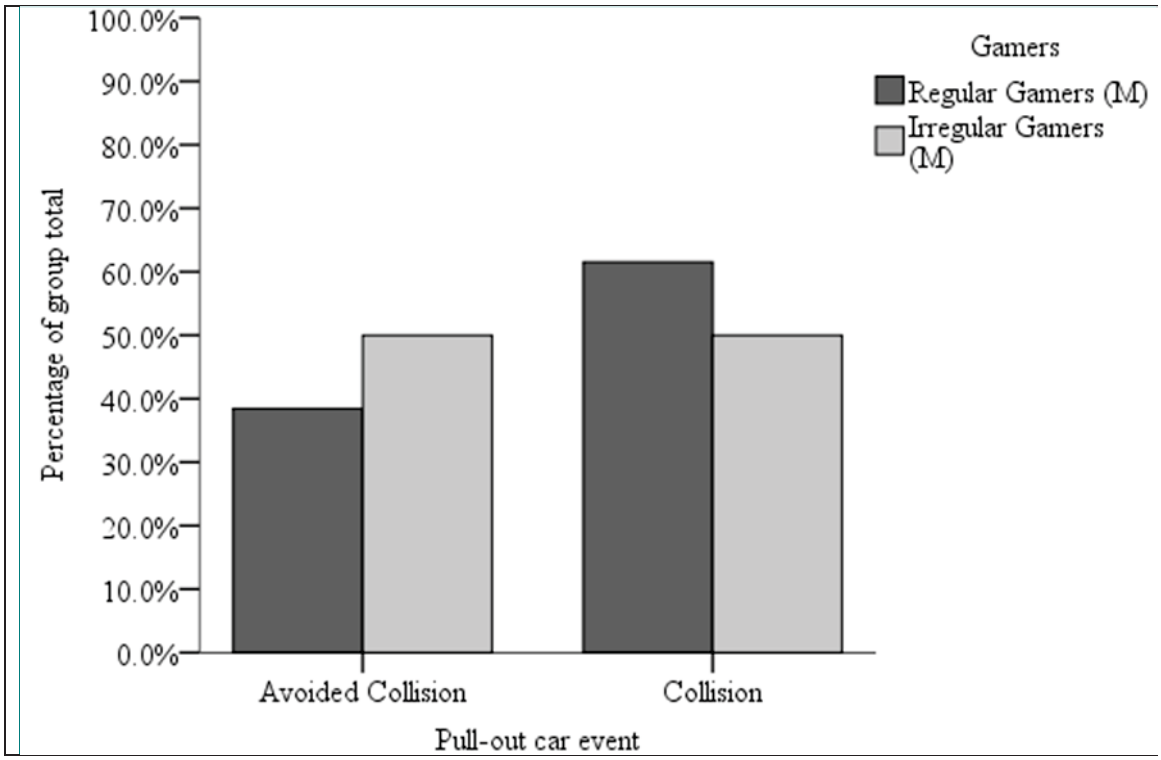

Figure 27. Percentage of collision rates for regular and irregular gamers.

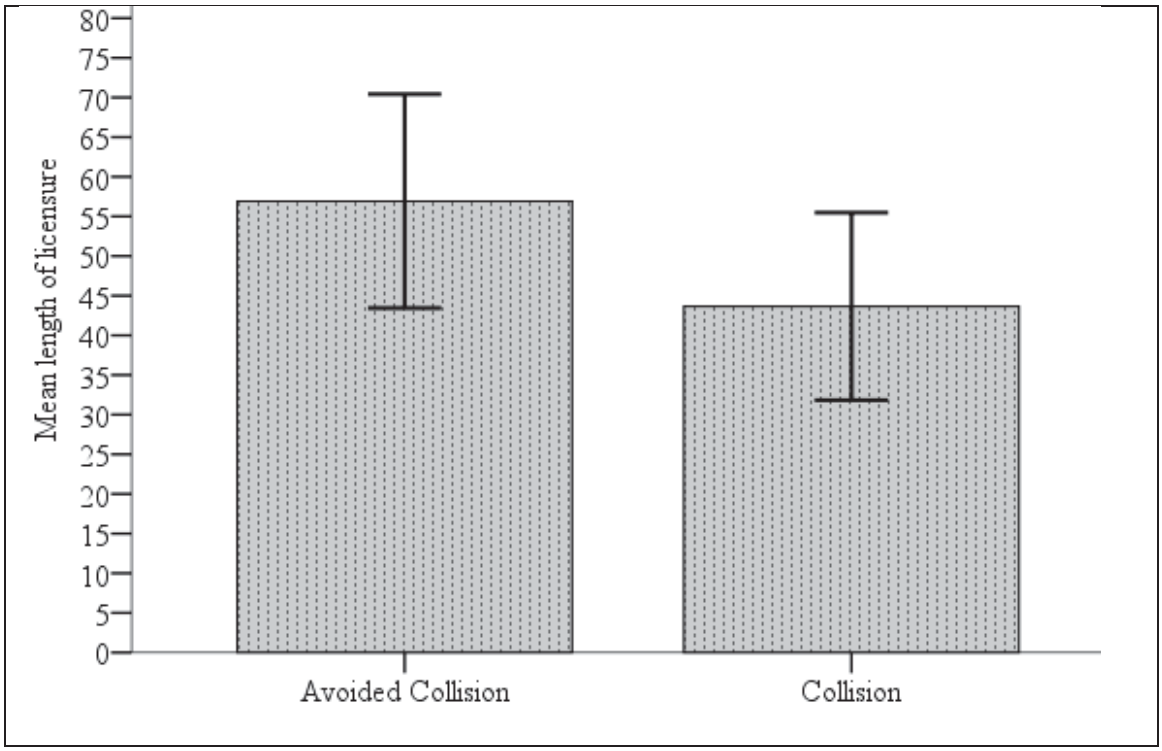

Figure 28. Relationship between length of licensure and collision outcome (Error Bars: +/- 2 SE).

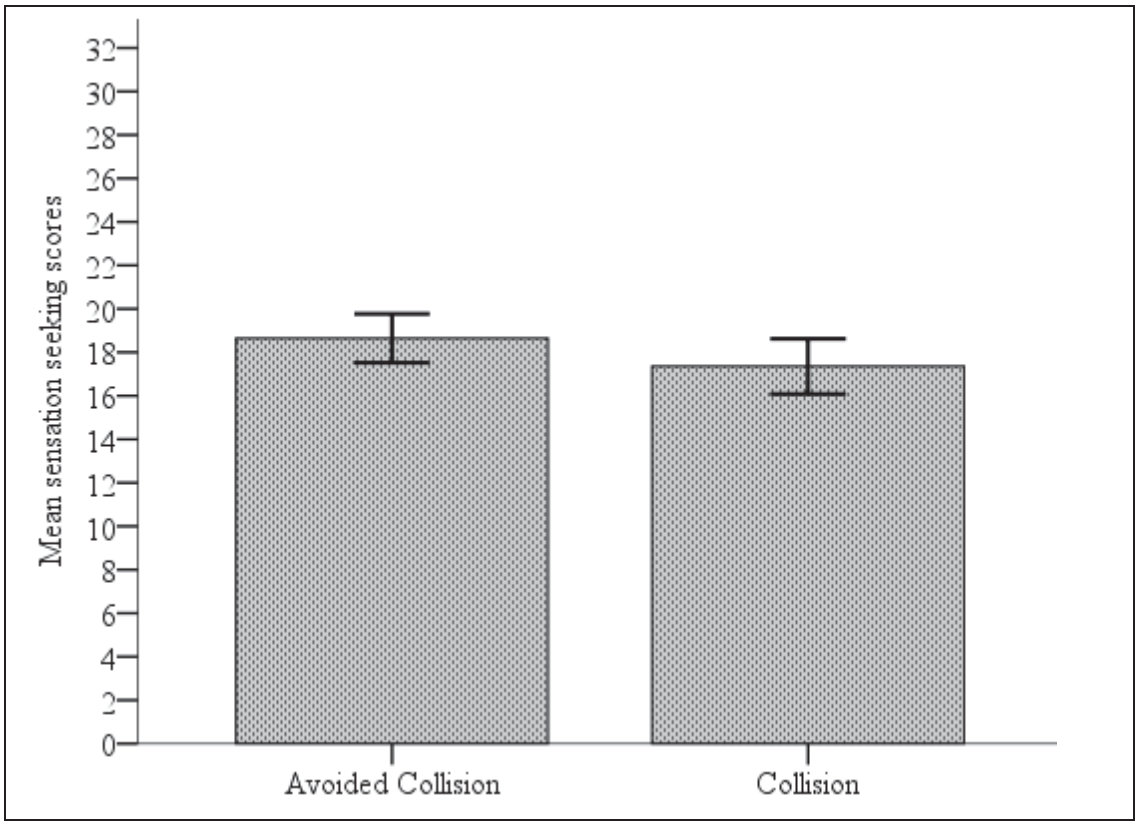

*Figure 29.*Relationship between sensation seeking and collision outcome (Error Bars: +/- 2 SE).

UCDS operating measures and collision outcome. Regular gamers were expected to be more likely to avoid a collision because they would exhibit faster response times and manoeuvring control. To understand contributing factors to the rear-end collision, a second stepwise-LR analysis was conducted to determine whether speed at the start of the event, perceptual response time (PRT) and the rate of deceleration predicted collision outcome.

Initial speed provided a good model fit, $\chi^2(8, N = 31) = 8.79$, $p = 0.36$, Nagelkerke $r^2 = 0.32$ with a 95% confidence interval ranging from 1.05 to 1.55.The inclusion of initial speed indicated that for every 0.25 km/h unit increase in speed, the odds of colliding with the pull-out car increased 1.23 times. The inclusion of the initial speed variable also improved the model classification from 56.3% (null model) to 75%

(full model). As one might expect, participants who were speeding were more likely to collide with the rear-end of the pull-out car. However this initial speed was not predictive of group membership of video gamer type. A one-way between-subjects ANOVA indicated that the initial speed of regular gamers (M = 54.1 km/h , SE = 1.55) and irregular gamers (M = 54.8 km/h, SE =1.32) at the start of the event did not significantly differ, $F(1, 30) = 0.12$, $p = 0.74$. Figure 30 shows the group means for initial speed for each group and collision outcome. Further, the group means indicated that the regular and irregular gamers actually drove within 5 km of the 50 km/h posted speed limit.

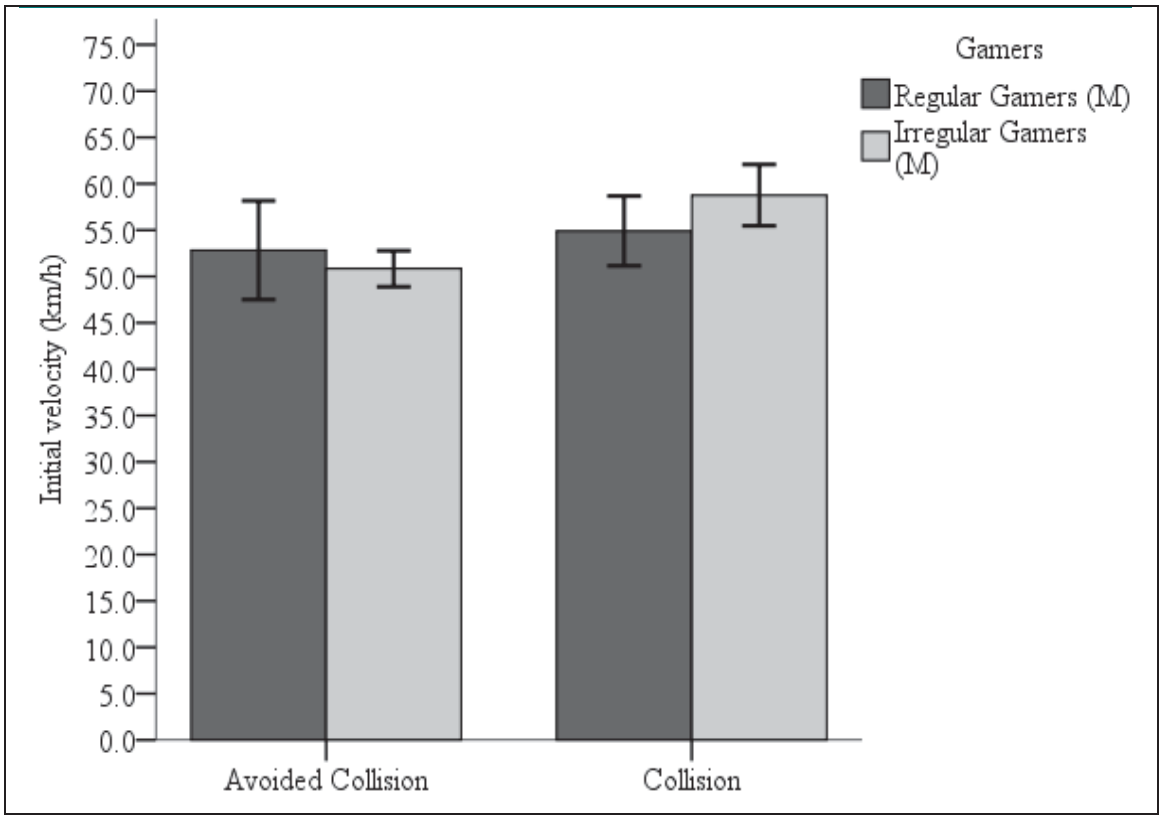

Figure 30. Average speed (km/h) at the moment the pull-out car event initiated and collision outcome (Error Bars: +/- 2 SE).

Tailgating the pull-out vehicle. After the rear-end collision event, the pull-out car would proceed on the roadway at 35km/hr. The average headway time participants followed at was analyzed to determine whether the variables were predictive of safe (> 2 seconds) or unsafe (< 2 seconds) headway time.

Overall 20 participants followed at an unsafe headway time, while 10 participants maintained a safe headway time. One participant was removed from the analysis because he drove out of the lane bounds and manoeuvred around the pull-out car. None of the predictor variables entered into the model were significant (Table 23). The main variable of interest, gamer type, was not predictive of following time with the pull-out car. Driver confidence was marginally significant ($p = 0.12$), and showed a trend that higher scores on the CQ were associated with safer headway times (Figure 31).

Table 23
Significance level of predictors for safe and unsafe headway time following the pull-out car.

Predictor Variable	**Significance level - Scenario 2**
Gamer type	$p = 0.79$
Sensation seeking scale scores	$p = 0.96$
IPIP-R risk-taking scores	$p = 0.67$
Driver confidence scores	$p = 0.12$
Length of licensure	$p = 0.84$

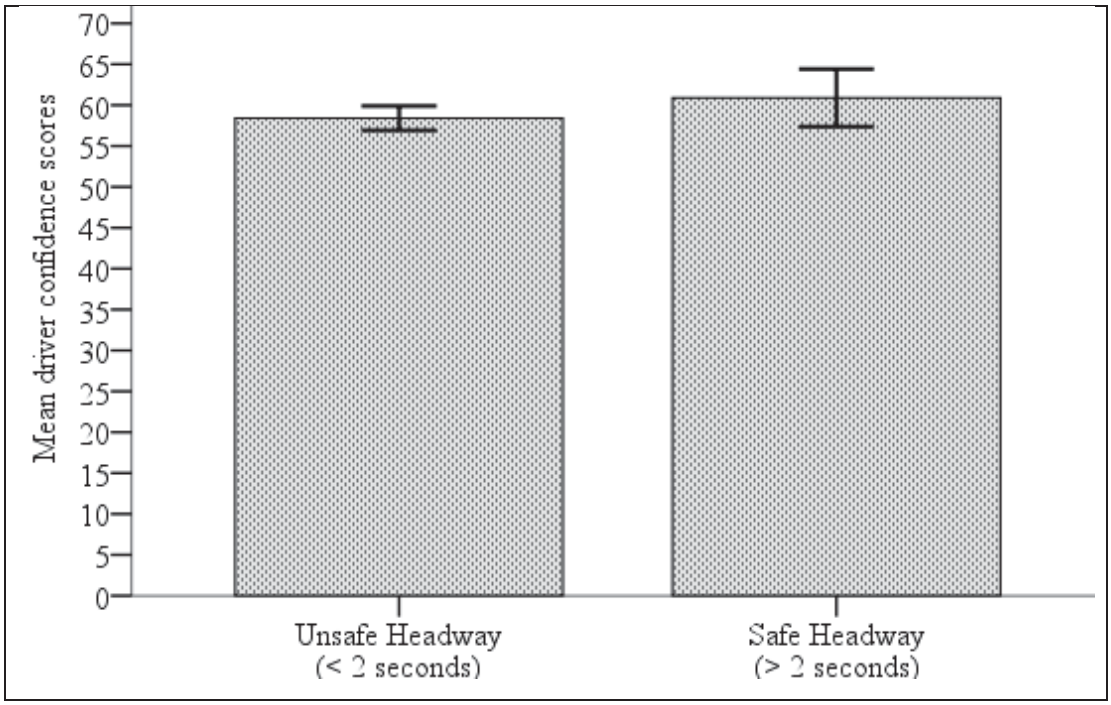

*Figure 31.*Mean driver confidence scores and safe or unsafe headway maintenance (Error Bars: +/- 2 SE).

Female non-gamers

The data from the female non-gamers (*n* = 15) was analyzed to determine whether group membership was significant when analyzed compared to th*e* male regular and irregular gamers. Data on the female non-gamer participants was collected from the same driving events presented to the male participants. Generally, female non-gamers were expected to exhibit low-risk driving behaviours compared to the male gamer groups.

Driving history. The number of traffic accidents and violations reported by the female non-gamers were examined (Table 24). A stepwise-LR analysis was conducted to determine whether predictors (driving experience, the number of vehicular accidents, at fault accidents and traffic violations) were predictive of group membership of female non-gamers and a collapsed (regular and irregular) male gamer group. The male gamers were collapsed into one group because the driving history between groups was not found

to be statistically significant. Collapsed male gamer groups were expected to report a significantly greater number of accidents and traffic violations than female non-gamers. The predictor variables however did not improve the null classification model and were not entered in the stepwise-LR model. This indicated that the female non-gamers did not differ from the male gamers on self-reported driving history (Table 25).

Table 24
Summary of the female non-gamer and collapsed gamers' driving experience and visual acuity.

			Past 5 Years			**Visual Acuity**	
	N	**Length of Licensure (SD)**	**Vehicular accidents (SD)**	**At fault accidents (SD)**	**Traffic violations (moving)(SD)**	**Left eye (SD)**	**Right eye (SD)**
Female non-gamers	15	52.33 (33.90)	0.67 (0.82)	0.27 (0.46)	1.00 (1.65)	1.16 (0.41)	1.20 (0.46)
Collapsed male gamers	31	49.65 (25.27)	0.35 (0.61)	0.19 (0.48)	1.68 (2.48)	1.30 (0.72)	1.29 (0.57)

Table 25
The significance level of by each predictor variable predicting group membership.

Predictor variable	**Significance level**
Length of licensure	$p = 0.76$
Number of vehicular accidents (past 5 years)	$p = 0.15$
At fault accidents (past 5 years)	$p = 0.62$
Traffic violations (moving)	$p = 0.33$

UCDS adaptation and vehicle control.

The nine BL measures for average speed, speed variance and SDLP were analyzed with a 3[group membership] x 9 [BL measure] RM ANOVA. The main interest of the analysis was on between-subject effects. However within-group effects and interaction effects are also reported.

Average speed. A G-G corrected 3[group membership] x 9[BL – average speed] RM ANOVA (with average speed as the within-subject variable) did not find the average speed of female non-gamers (M = 55.2 km/h, SE =0.84) to be significantly different from regular gamers (M = 53.8 km/h, SE = 0.90) or irregular gamers (M = 54.7 km/h, SE = 0.97) ($F(2,42) = 0.44$, $p = 0.65$)(Figure 31.).

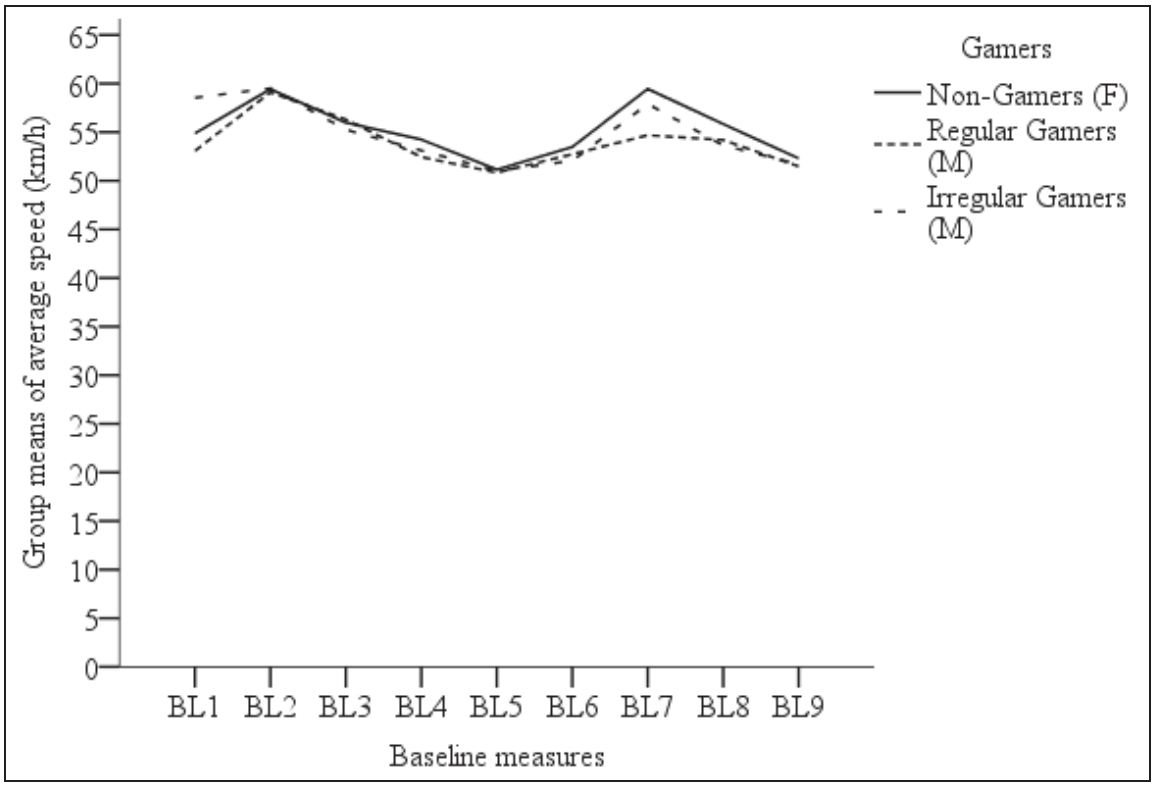

Figure 31. Group means of average speed across BL measures.

However, the within-subjects effects average speed across the BL measures was found to be significant ($F(4, 190) = 18.00$, $p < 0.001$). Post-hoc tests revealed that there were instances where the female non-gamers experienced significant ($p < 0.05$ with a Bonferroni correction) average speed differences among the BL measures. These instances are listed in Table 26. It appears that average speed at BL2, BL5 and BL7 had the greatest difference across the nine BL measures. However when all BL means are considered, the differences may not have practical significant because they were all

within 10 km of the posted speed limit (Table 27) and at times had negligible mean differences even though they were statistically significant (e.g. 3.1 km/h and 4.7 km/h).

Table 26
Female non-gamer' significant post-hoc pairwise comparisons for BL average speed measures.

BL - Average speed km/h	**BL - Average speed km/h**	**Mean difference**	**p-level**
BL2 -59.4 km/h	BL5 - 51.2 km/h	8.3 km/h	$p < 0.001$
	BL6 - 53.5 km/h	6.0 km/h	$p = 0.04$
	BL9 - 52.3 km/h	7.1 km/h	$p = 0.01$
BL5 - 51.2 km/h	BL4 - 54.2 km/h	3.1 km/h	$p = 0.01$
	BL8 - 55.8 km/h	4.7 km/h	$p < 0.001$
BL7- 59.5 km/h	BL4 - 54.2 km/h	5.2 km/h	$p = 0.01$
	BL5 - 51.2 km/h	8.3 km/h	$p < 0.001$
	BL6 - 53.5 km/h	6.0 km/h	$p = 0.003$
	BL9 - 52.3 km/h	7.2 km/h	$p < 0.001$

Table 27
Descriptive statistics of female non-gamers' average speeds across BL measures.

Baseline	**Average speed**	**SD**	**SE**
BL1	54.9 km/h	4.81	1.95
BL2	59.4 km/h	7.71	1.82
BL3	56.0 km/h	6.10	1.84
BL4	54.2 km/h	3.73	1.13
BL5	51.2 km/h	4.00	0.85
BL6	53.5 km/h	2.19	0.65
BL7	59.5 km/h	5.47	1.49
BL8	55.8 km/h	3.75	1.10
BL9	52.3 km/h	4.54	0.99

Mean speed variance. A G-G corrected 3[group membership] x 9[BL – speed variance] (with average speed variance as the within-subject variable) examined the speed maintenance of the female non-gamers in comparison to the male gamers. The analysis did not find the female non-gamers (M = 5.5 km/h, SE = 0.56) to differ significantly from the regular gamers (M = 3.86 km/h, SE = 0.60) or irregular gamers (M = 4.7 km/h, SE = 0.53) ($F(2,42) = 1.75$, $p = 0.19$).

The analysis found that significant within-subject effects ($F(3,129) = 21.5$, $p < 0.001$). Post-hoc tests revealed four instances where the speed variance for female non-gamers significantly differed ($p < 0.05$ with a Bonferroni correction) between BL2 and other BL measures (Table 28).These results suggest that speed maintenance near the beginning of the practice drive was the most variable, but improved across BL measures (Figure 32). Overall, the groups exhibited a similar patterns of speed variance across the BL measures which likely indicates that all groups likely adapted to the UCDS at similar rates or that the within-group differences are related to the virtual driving environment. Table 29 provides a list descriptive statistics for the speed variance of female non-gamers across BL measures.

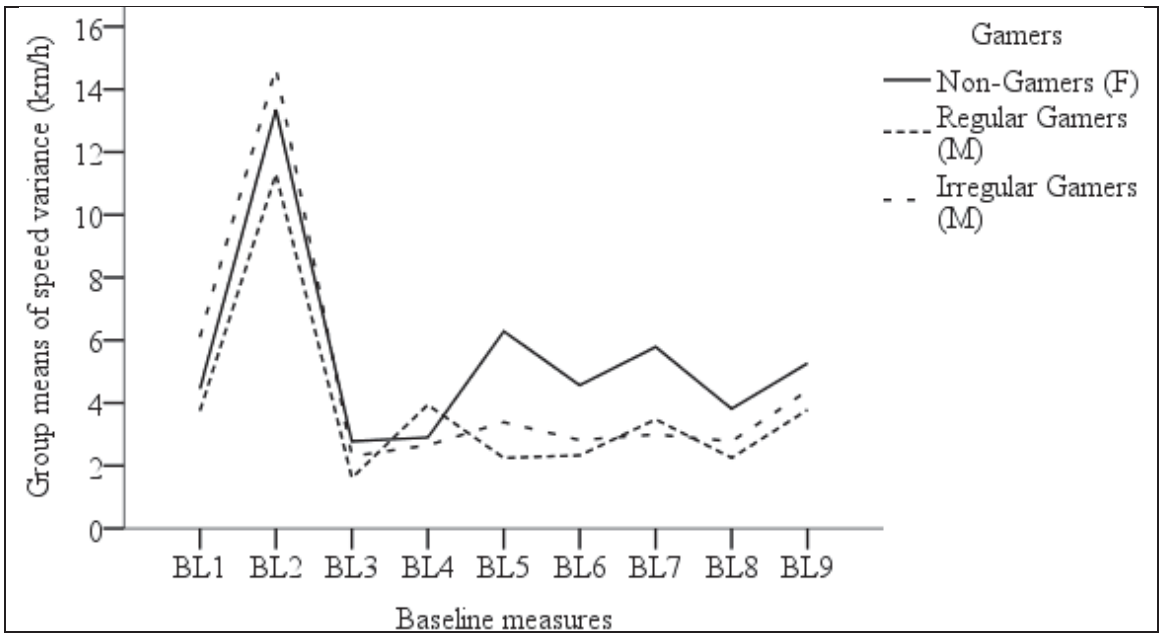

Figure 32. Group means of speed variance across BL measures.

Table 28
Female non-gamers' significant post-hoc pairwise comparisons for BL average speed variances.

BL – Speed variance km/h	**BL – Speed variance km/h**	**Difference**	**p-level**
BL2 -13.4 km/h	BL3 - 2.8 km/h	10.6 km/h	p = 0.01
	BL4 - 2.9 km/h	10.4 km/h	p = 0.01
	BL6 - 4.6 km/h	8.8 km/h	p = 0.04
	BL8 – 3.8 km/h	9.5 km/h	p = 0.02

Table 29
Descriptive statistics for female non-gamers average speed variance across BL measures.

Baseline	**Average speed**	**SD**	**SE**
BL1	4.5 km/h	5.64	1.49
BL2	13.4 km/h	9.05	2.54
BL3	2.8 km/h	1.86	0.45
BL4	2.9 km/h	2.18	0.81
BL5	6.3 km/h	7.00	1.17
BL6	4.6 km/h	3.04	0.60
BL7	5.8 km/h	5.61	1.08
BL8	3.8 km/h	2.08	0.56
BL9	5.3 km/h	3.74	0.96

SDLP. A G-G corrected 3[group membership] x 9[BL –SDLP] RM ANOVA (with SDLP as the within-subject variable) did not find female non-gamers (M = 0.10, SE = 0.01) to be significantly different from regular gamers (M = 0.09, SE0.01) or irregular gamers (M = 0.11, SE = 0.01) (F(2,42) = 1.87, p = 0.17). Again, within-subjects effects were found to be significant (F(8, 244) = 5.00, p < 0.001). Post-hoc tests revealed that SDLP was only significant between BL1 (M = 0.13, SE = 0.02) and BL3 (M = 0.09, SE = 0.01) (p = 0.02 with a Bonferroni correction) for the female non-gamers. This indicates that the female non-gamers generally had consistent control of their lane position throughout the driving scenarios. Once again, all participant groups exhibited a similar pattern across the BL measures which might indicate similar adaptation to the UCDS or effects due the virtual environment (Figure 33).

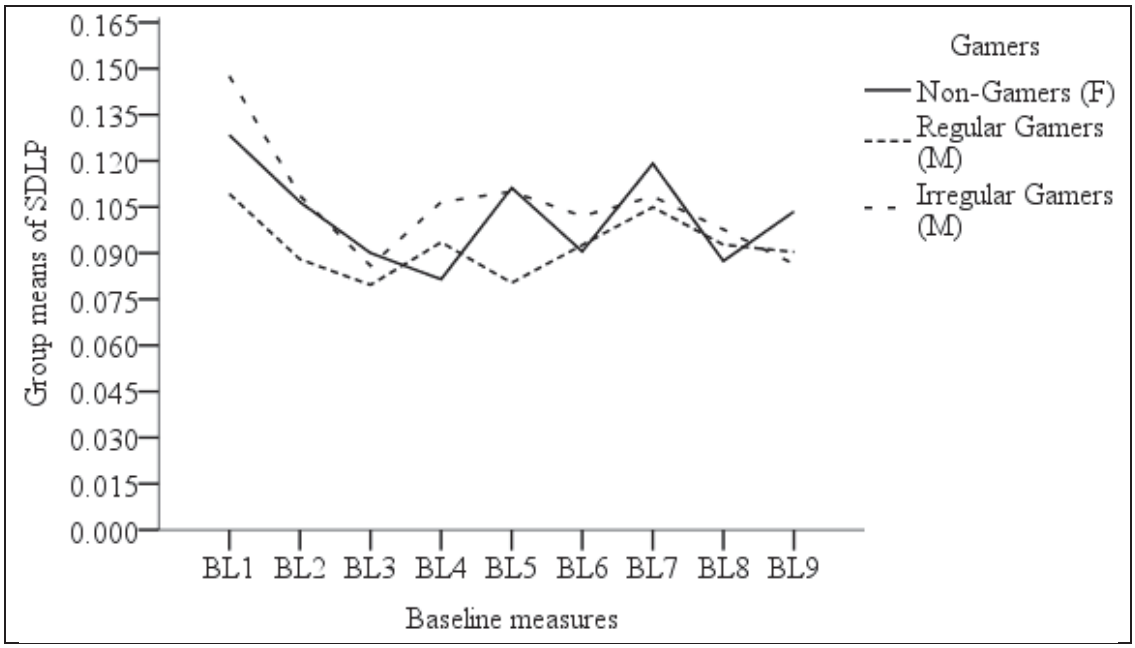

Figure 33. Group means for SDLP across the nine BL measures.

Reduce speed event (RSE)

Three cases are missing from the analysis (one female non-gamer, one regular gamer and one irregular gamer) because of data collection error in which the UCDS stopped collecting data partway through the driving scenario.

Deceleration profiles. Deceleration profiles were analyzed with a G-G corrected 3[group membership] x 4[RSE- deceleration] RM ANOVA (with deceleration as the within-subject variable).The deceleration profiles for female non-gamers (M = -1.31 km/h^2, SE = 0.12) was not significantly different from regular gamers (M = -1.47 km/h^2, SE = 0.13) or irregular gamers (M = -1.63 km/h^2, SE = 0.10) ($F(2,40) = 2.18$, $p = 0.13$) (Figure 34). The within-subject effects of deceleration across each RSE was significant ($F(3, 103) = 53.43$, $p < 0.001$). Table 30 lists the descriptive statistics for the deceleration profiles of female non-gamers. Post-hoc pairwise comparisons found that deceleration profiles were significant ($p < 0.05$ with Bonferroni adjustment) between RSE3 and all other RSE (Table 31). No significant interaction effects were present ($F(5, 103) = 1.33$, p

= 0.26). Overall the deceleration of the female non-gamers across RSE paralleled that of the male gamers. The within-subject effect of deceleration at the RSE3 will be further explored in the discussion.

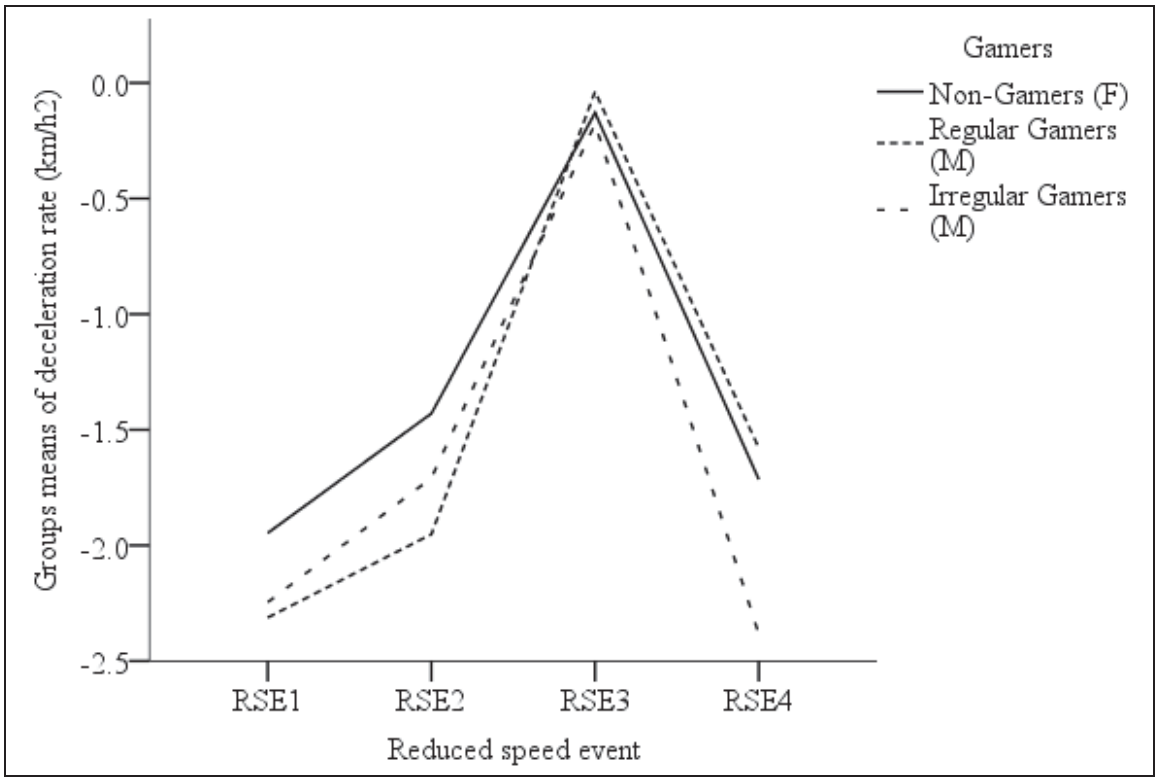

Figure 34. Groups means for deceleration rates across the four RSE.

Table 30

Descriptive statistics for deceleration rates across the four RSE for female non-gamers.

	Deceleration	**SD**	**SE**
RSE1	$^{-}$1.95 km/h^2	0.43	0.29
RSE2	$^{-}$1.43km/h^2	0.27	0.18
RSE3	$^{-}$0.13km/h^2	0.17	0.11
RSE4	$^{-}$1.72km/h^2	0.38	0.26

Table 31
Female non-gamers' post-hoc pairwise comparisons of deceleration rates across RSE.

RSE - Deceleration	**RSE - Deceleration**	**Mean Difference**	**p-level**
RSE3 - ¯¯0.13km/h^2	RSE1 - ¯ 1.95 km/h^2	1.82 km/h^2	$p < 0.001$
	RSE3 - ¯1.43 km/h^2	1.30 km/h^2	$p < 0.001$
	RSE4 - ¯1.72 km/h^2	1.59 km/h^2	$p < 0.001$

Speed at the reduced speed limit sign. Participant speed once they reached the new posted speed limit was analyzed with a G-G corrected 3[group membership] x 4[RSE- speed at new posted speed limit] RM ANOVA (with speed as the within-subject variable). Group speeds at the new posted speed limit did not differ between female non-gamers (M = 76.0 km/h, SE = 1.59) and the regular gamers (M = 77.1 km/h, SE = 1.71) or irregular gamers (M = 75.6 km/h, SE = 1.50) ($F(2, 40) = 0.20$, $p = 0.82$). The within-subject effects of speed was also not significant ($F(2, 98) = 2.01$, $p = 0.13$) which indicated that the participant groups had fairly consistent speeds across the RSE by the time they reached the new posted speed limit. Finally, the interaction effect was marginally significant ($F(5, 98) = 2.12$, $p = 0.07$). Post-host pairwise comparison indicated that this trend was between the regular and irregular gamer and was previously reported.

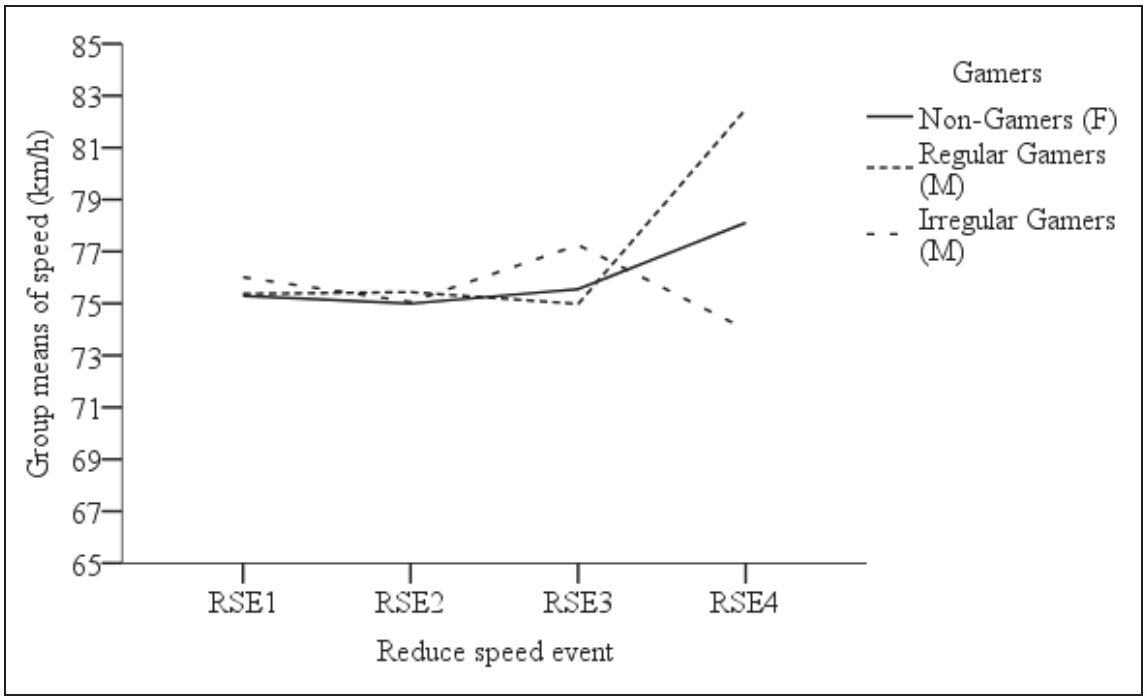

Figure 35. Group speeds at the new posted speed sign across the four RSE. **Note**: the origin of this graph is 65 km/h.

Driving events

The female non-gamers also completed the same driving events as the male gamer groups. Since gamer type was not found to significantly predict the outcome of the driving events in the previous result, the regular and irregular male gamer groups were collapsed into one group (n = 31) and entered in the stepwise-LR model as a categorical variable with the female non-gamer group.

Late yellow light event.

Anticipation and indecision. Due to the poor distribution of observed cases in each outcome variable (less than 15% in one of the outcome cells) the anticipation and indecision behaviours were not analyzed. Only one female participant exhibited both anticipatory and indecision during scenario 1; she did not repeat this behaviour in scenario 2.

Stop/go decision. Observed outcomes for the late yellow light also had a poor distribution between stop/go outcomes. Only three females in scenario 1 and two females in scenario 2 stopped at the late yellow light. The predictor variables were entered into a stepwise-LR model to analyze whether group membership was predictive of stop/go outcome in the experimental driving scenarios.

In scenario 1, 20% of the participants (three female non-gamers and six male gamers) stopped at the late yellow light while 80% of the participants (12 female non-games and 25 male gamers) ran the late yellow light. Group membership (female non-gamers or male gamers) did not significantly predict stop/go outcome (p = 0.96). Further, none of the predictor variables entered into the analysis were determined to predict stop/go outcome in either driving scenario (Table 32). Driver confidence scores did trend towards significance (p = 0.13) indicating a possible relationship where higher scores on the driver confidence questionnaire were associated with stopping behaviour (Figure 36).

Table 32
Significance of predictor variables on stop/go outcome variable at the late yellow light event.

Predictor variable	**Scenario 1**	**Scenario 2**
Group membership	0.96	0.81
Sensation seeking scale scores	0.41	0.16
IPIP-R risk-taking scores	0.67	0.89
Driver confidence scores	0.13	0.03
Length of licensure	0.96	0.73

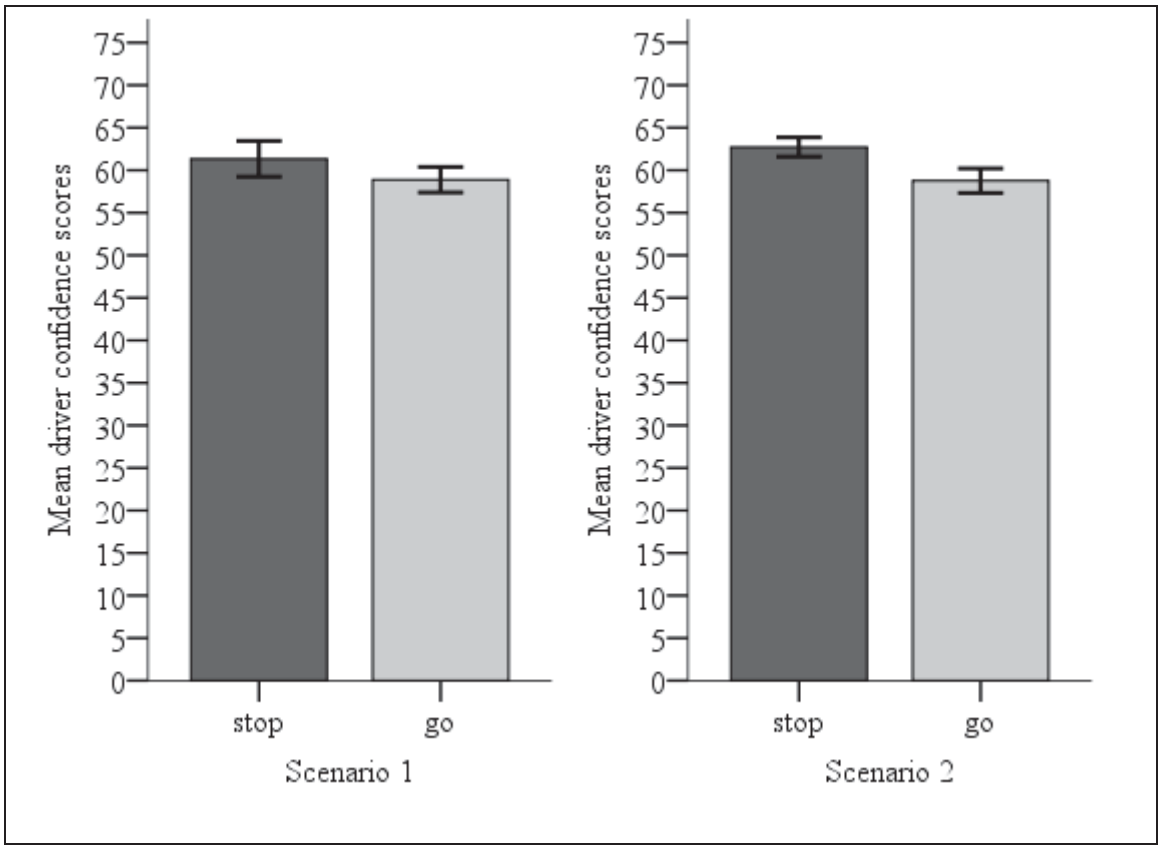

Figure 36. Mean driver confidence scores and stop/go outcome at the late yellow light event in scenario 1 and scenario 2 (Error Bars: +/- 2 SE).

In scenario 2, only 15% of the participants (two female non-gamers and five male gamers) stopped at the late yellow light. Group membership did not predict the outcome variable (p = 0.81). Driver confidence scores were found to predict stop/go outcome (p = 0.03) at the late yellow light (Figure 36). Driver confidence scores were entered into the full logistic regression model to test against the null model and found to be statistically significant. This indicated that the driver confidence predictor distinguished between stop/go outcome behaviours ($\chi 2$ = 6.19, p = 0.01 with df = 1). The Wald criterion indicated that driver confidence scores made significant contributions to prediction ($\chi^2(1, N = 46) = 4.34$, p = 0.04, with a 95% confidence interval ranging from 0.55 to 0.98). However, Nagelkerke's r^2 of 0.22 indicated that the relationship between driver confidence scores as a predictor of stop/go outcome to be weak. The Exp(B) odds ratio

(0.73) also indicated that for every unit increase in driver confidence scores the participant was 0.27 times less likely to run the yellow light. However the overall success of the classification model was negligible. Prediction success overall was 80.4% (0% for stopping behaviour and 94.9% for proceeding through the intersection) which was worse than the null model that had an overall success of 84.8% (0% for stop and 100% for go behaviour). A case-wise analysis determined that the inclusion of the driver confidence variable increased type II errors. Despite the statistical significance, an examination of driver confidence scores revealed that it was not actually a useful predictor.

Intersection clearance. All drivers that ran the yellow light cleared the intersection before the light turned red.

Left turn event

Completed turn across traffic or waited. In scenario 1 and scenario 2, the stepwise-LR model did not enter any of the predictor variables into the full model (Table 33). The majority of participants completed the turn across traffic (78% in scenario1 and 76% in scenario 2). Figure 37 and Figure 38 show the percentage of males and females who turned or waited for the traffic to clear before completing the left turn. While none of the predictor variables were significant, length of licensure appeared to trend towards significance in scenario 2. However the large amount of variance likely diminishes any consistent patterns that might be seen with this trend.

Table 33
Significance of predictor variables on turning outcome variable in scenario 1 & 2.

Predictor variable	**Scenario 1**	**Scenario 2**
Group membership	$p = 0.57$	$p = 0.30$
Sensation seeking scale scores	$p = 0.21$	$p = 0.23$
IPIP-R risk-taking scores	$p = 0.95$	$p = 0.83$
Driver confidence scores	$p = 0.23$	$p = 0.30$
Length of licensure	$p = 0.40$	$p = 0.10$

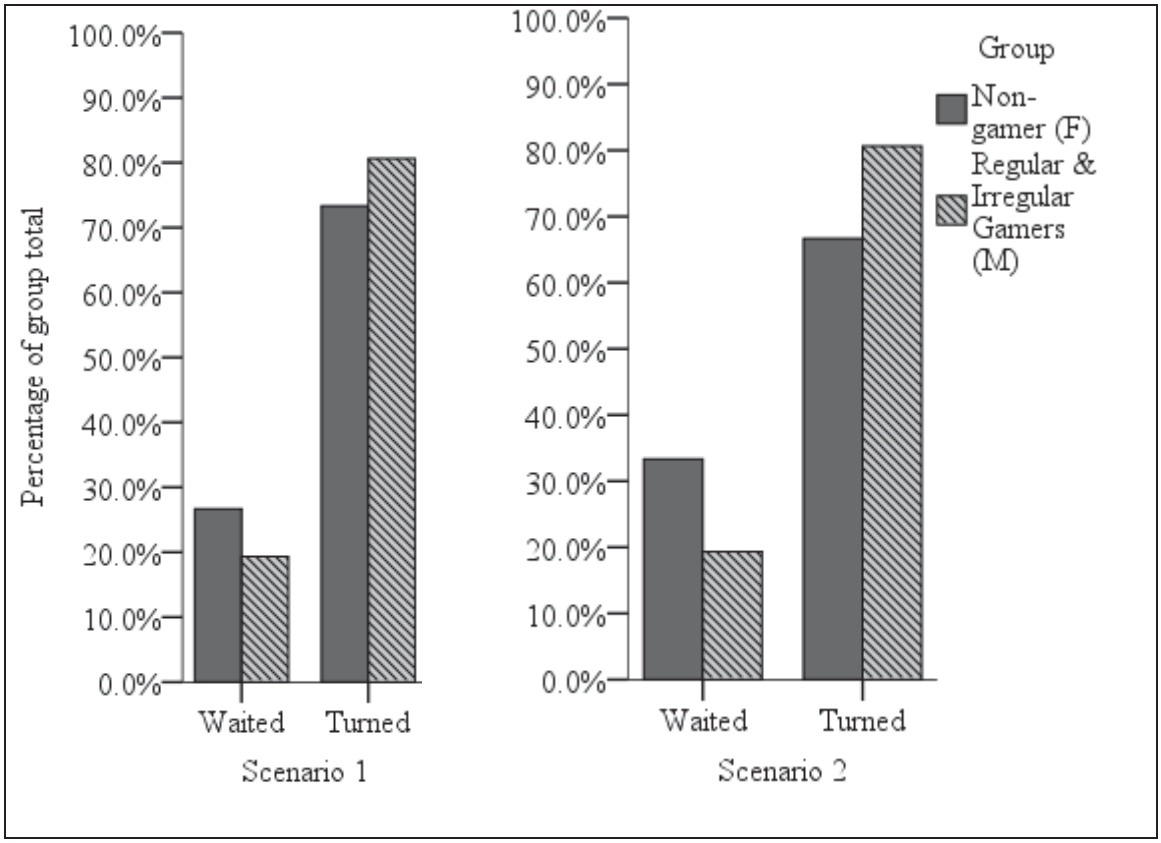

Figure 37. Percentage of participants who completed a left turn across oncoming traffic or waited for the oncoming traffic to clear in scenario 1 and scenario 2.

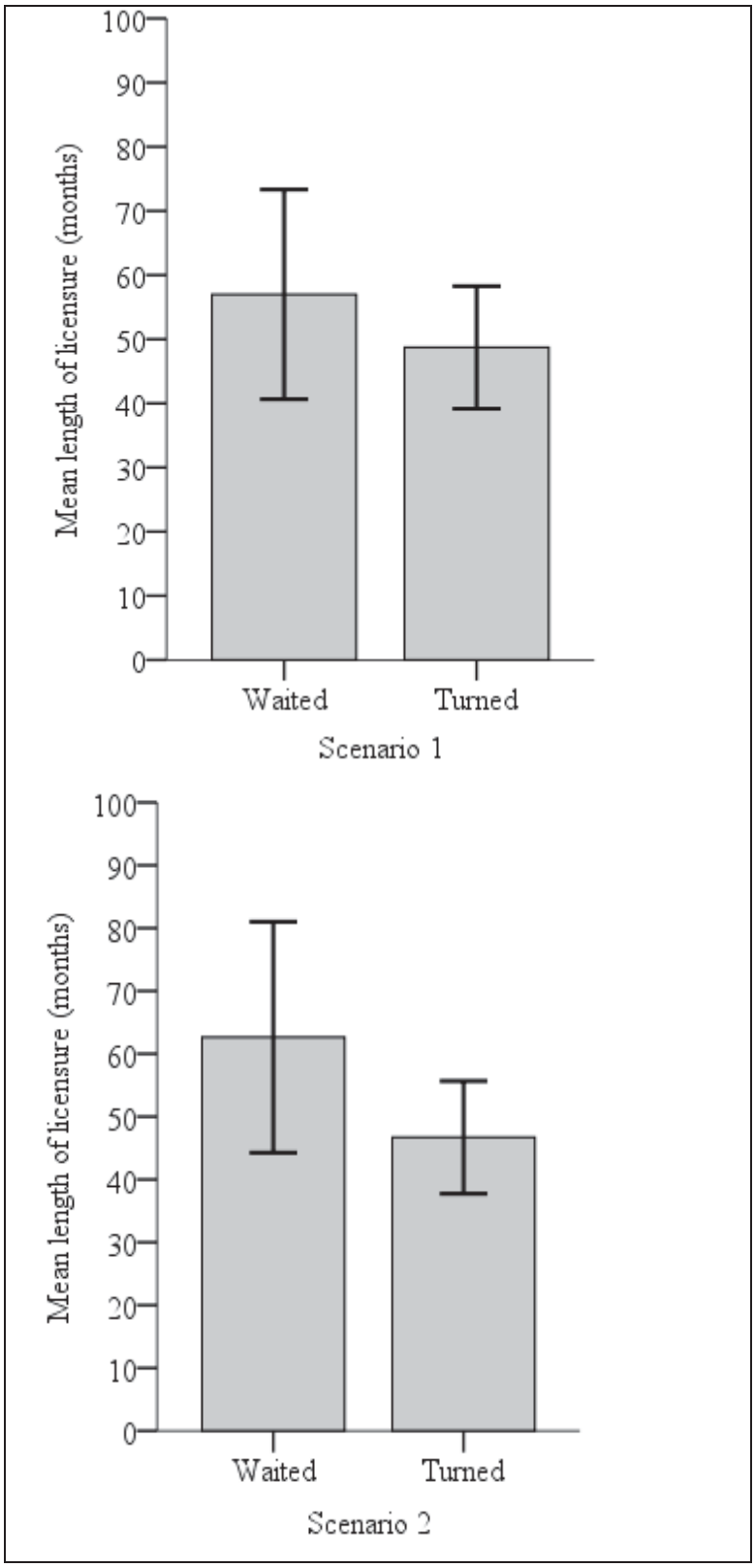

Figure 38. The relationship between length of licensure and outcome behaviour for waiting or turning across traffic to complete a left turn (Error Bars: +/- 2 SE).

Repeated-measures of gap acceptance. The actual time gaps that participants chose to initiate the left turn was also analyzed using a 2[group membership]x 2[scenario – selected time gap] RM ANOVA (with the selected time gap as the within-subject variable) to determine whether actual gap acceptance was significantly different between the female non-gamers and male gamers or if the participant groups changed their gap acceptance between scenarios. Figure 39 and Figure 40 show the percentage of gap acceptance for participant groups in each scenario.

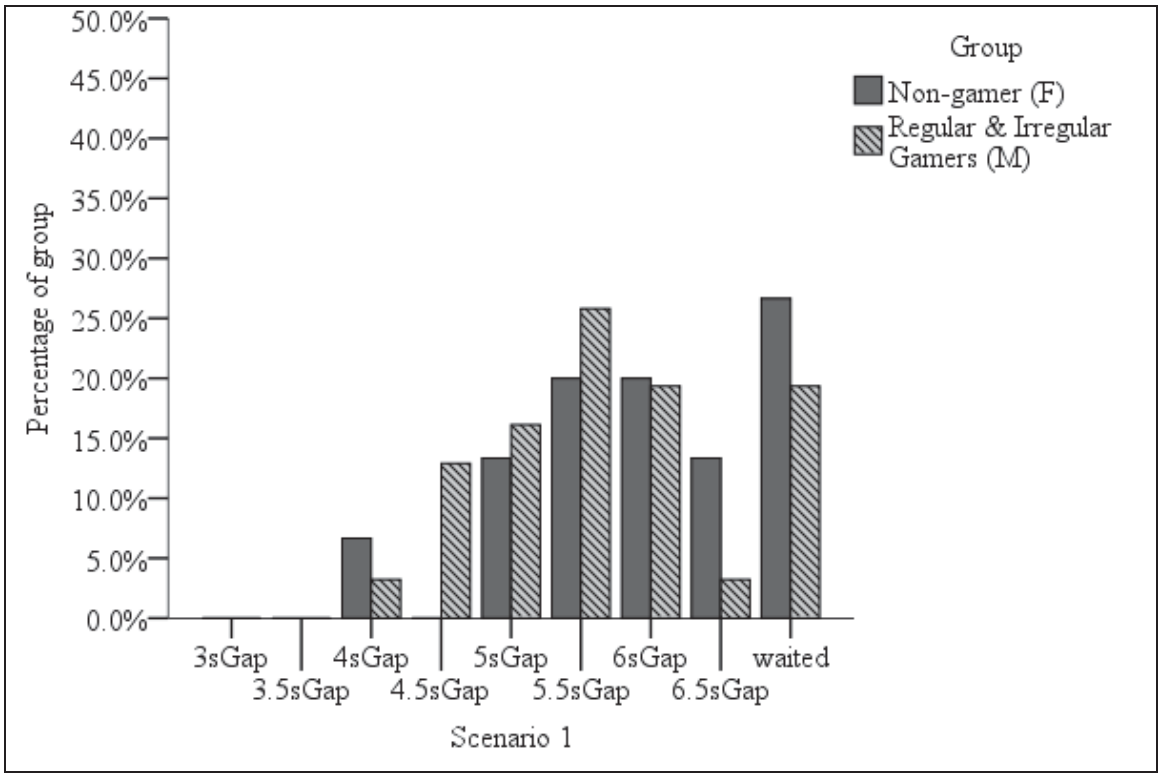

Figure 39. Scenario 1 group percentages of gap acceptance choice.

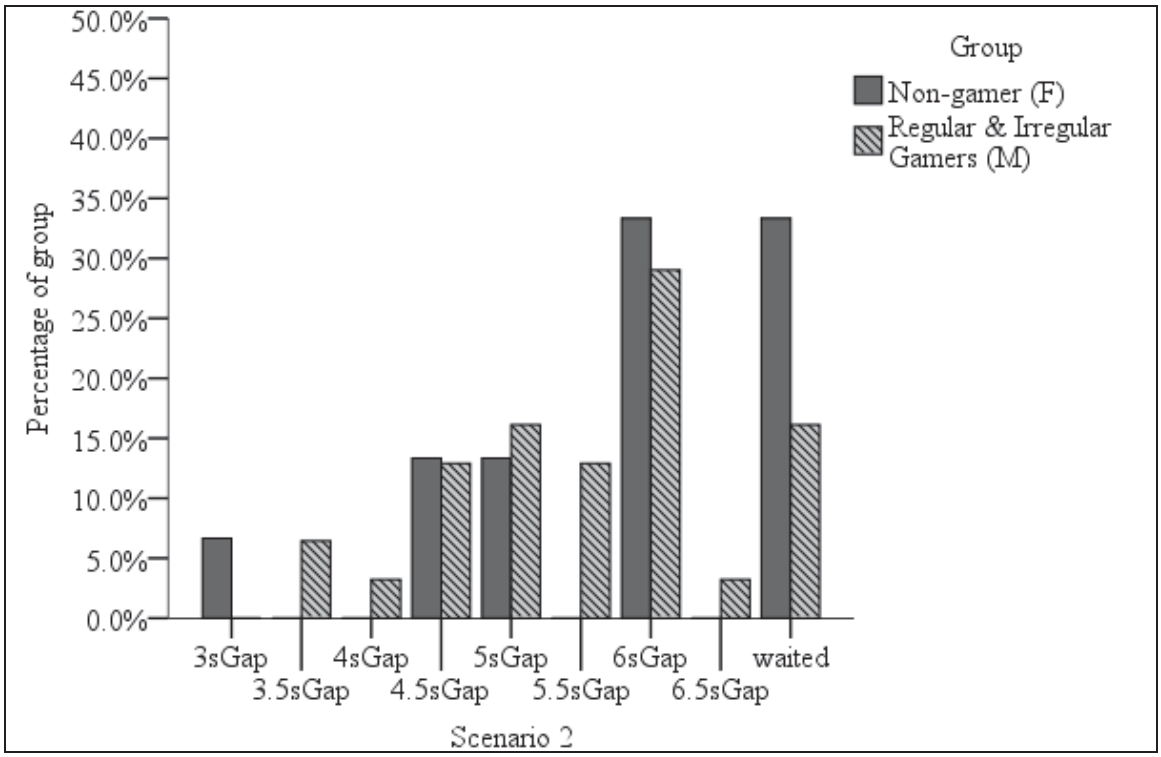

Figure 40. Scenario 2 group percentages of gap acceptance choice

The female non-gamers (M = 5.88 s, SE = 0.24) and male gamers (M = 5.60 s, SE = 0.17) did not significantly differ on gap acceptance, $F(1, 44) = 0.98$, $p = 0.33$. Similarly, there was no significant within-subjects effect of scenario, $F(1,44) = 0.03$, $p = 0.85$, or interactions, $F(1, 44) = 0.21$, $p = 0.65$. Finally, no group by scenario interaction effects were found, $F(1, 44) = 0.29$, $p = 0.60$. This indicates that the participants did not change their gap acceptance significantly between the driving scenarios.

Collisions during the left turn event. While some participants crossed traffic with high-risk time gaps, none of the participants collided with oncoming traffic.

Tailgating event

Tailgating behaviour was analyzed to determine whether group membership was predictive of safe or unsafe headway times when following behind a vehicle travelling at 35 km/h (15 km below the posted speed limit). The predictor variables entered into the logistic did not adequately predict outcome and were not entered into the full classification model (Table 34). Nine of the female non-gamers followed the slow vehicle with less than 2 seconds of average headway time, while 6 followed with a mean headway time greater than 2 seconds. Overall, 24 participants followed the slow car at unsafe headway time while 21 did follow at a safe headway time (Figure 41).

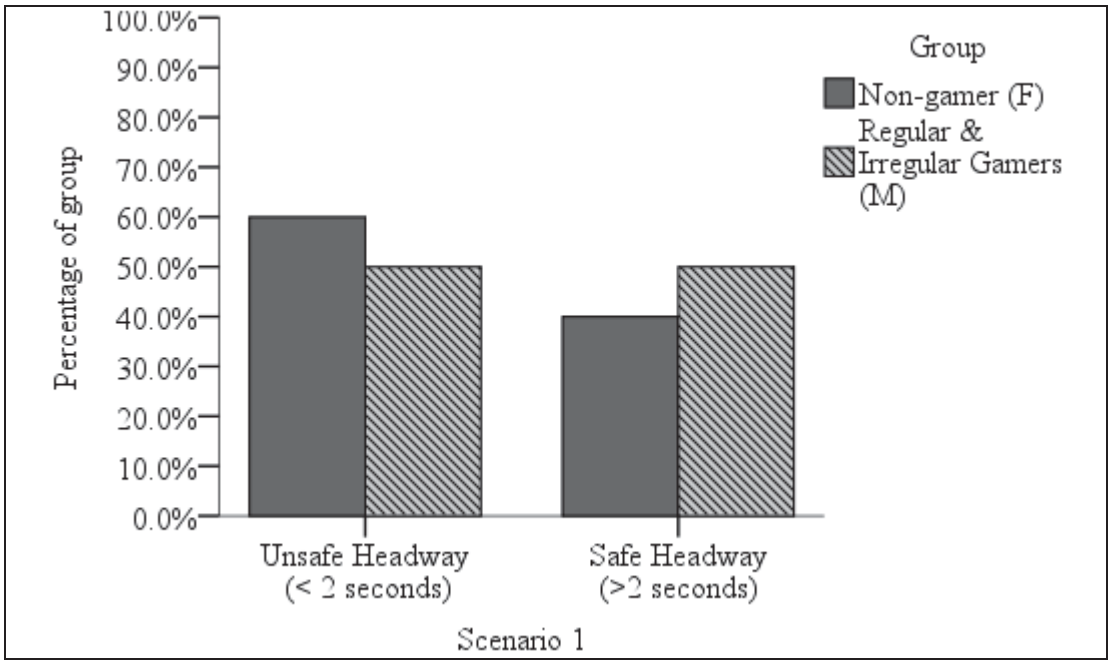

Figure 41. Group Percentages of safe and unsafe mean headway times following the slow moving vehicle.

Table 34
Significance of predictor variables on safe/unsafe headway time in scenario 1 tailgating event.

Predictor Variable	**Significance Scenario 1**
Group membership	$p = 0.53$
Sensation seeking scale scores	$p = 0.87$
IPIP-R risk-taking scores	$p = 0.75$
Driver confidence scores	$p = 0.74$
Length of licensure	$p = 0.98$

Pull-out event.

Rear-end collision with the pull-out car. The predictor variable 'length of licensure' was found to be significant ($p = 0.04$) in stepwise logistical model analyzing collision outcome and was entered in the full classification model. While no other predictor variables were entered into the analysis, group membership trended towards significance ($p = 0.10$) (*Table 35*). Specific to the female non-gamers, three participants successfully avoided a rear-end collision with the pull-out car while 12 had a rear-end

collision. Overall there were 17 observations where no collision occurred and 29 observations where a rear-end collision did occur (Figure 42).

Table 35
Significance of predictor variables on collision outcome with the pull-out car.

Predictor Variable	**Significance level**
Group membership	$p = 0.10$
Sensation seeking scale scores	$p = 0.37$
IPIP-R risk-taking scores	$p = 0.88$
Driver confidence scores	$p = 0.98$
Length of licensure	$p = 0.04$

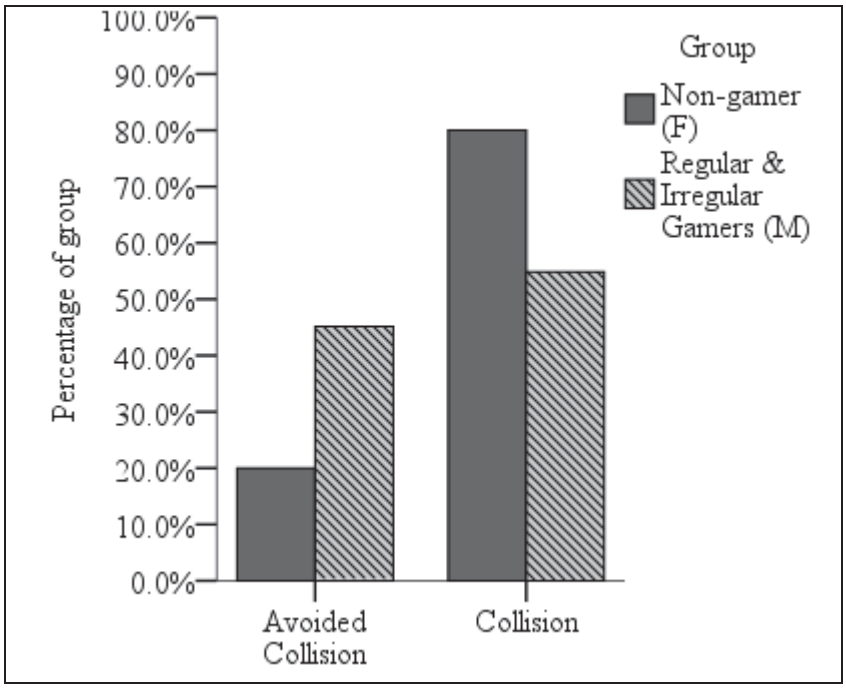

Figure 42. Group percentages of successful collision avoidance or collision with the pull-out car.

A test of the full model with length of licensure entered was found to be a statistically significant improvement from the null model which indicated that length of licensure predicted collision outcome ($\chi 2 = 4.20$, $p = 0.04$ with $df = 1$). The Wald criterion indicated that length of licensure was significant to outcome prediction ($\chi^2(1, N = 46) = 3.80$, $p = 0.05$, with a 95% confidence interval ranging from 0.95 to 1.0).

However, Nagelkerke's r^2 of 0.20 indicated a weak relationship between outcome prediction and length of licensure. The odds ratio also indicated that when length of licensure is raised by 1 unit (1 month) the odds of colliding are 0.02 times less likely. Prediction success was not great; successful prediction was 63% with the full model (24% avoiding a collision and 86% for having a collision). This was identical to the null model which also had an overall success rate of 63%, which indicates that the inclusion of license length as a predictor variable did not practically improve the null model. Figure 43 shows the relationship between 'length of licensure' and collision outcome; the error bars indicate that there was vast variability which may have erased substantive differences.

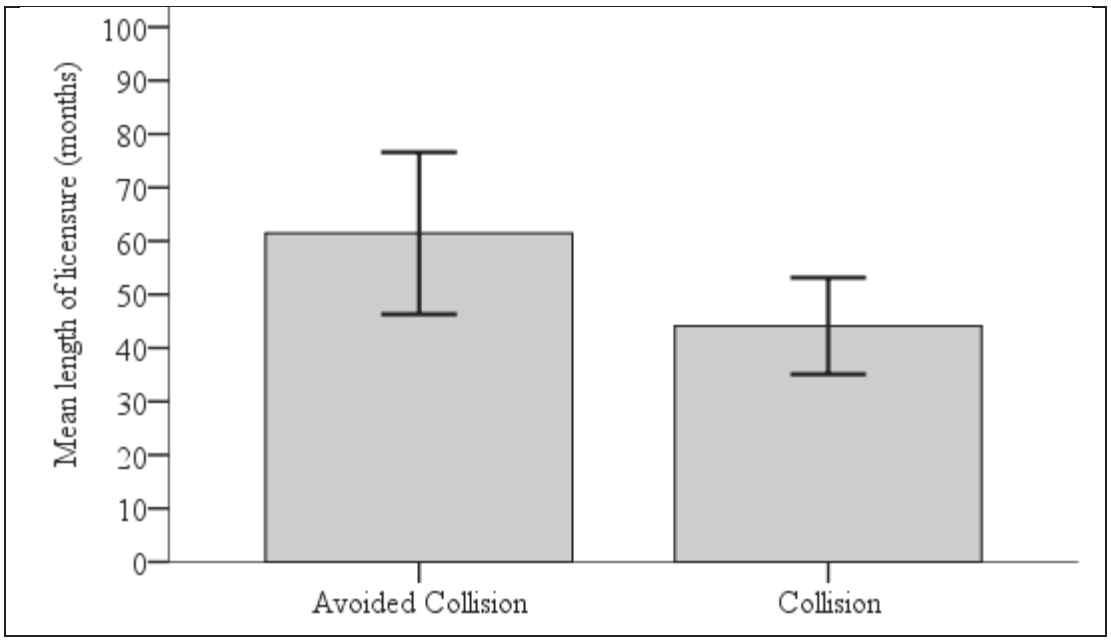

Figure 43. The relationship of reported length of licensure and collision outcome (Error Bars: +/- 2 SE).

Group membership trended towards significance after the variance for 'length of licensure' was accounted for (p = 0.06). This trend indicated that female non-gamers were more likely to have a collision with the pull-out car. However the poor distribution

between outcome cells and large differences in group sizes are likely the reason for this trend.

Tailgating the pull-out vehicle. Safe/unsafe tailgating behaviour was also after the pull-out car continued to drive at 35 km/h in front of the participant. Four participants (three females and one male) were not entered into the stepwise-LR analysis because they got ahead of the pull-out car. None of the predictor variables were significant and therefore not entered into the full logistic regression model (Table 36). Of the female non-gamers, five followed the pull-out car with less than 2 seconds of headway time while 12 followed at a safe headway time greater than 2 seconds. Three of the female non-gamers got ahead of the pull-out car during the collision event; these participants passed through the pull-out car during the collision event.

Table 36
Significance of predictor variables on headway time (safe/unsafe) outcome.

Predictor variables	**Significance level Scenario 2**
Group membership	$p = 0.14$
Sensation seeking scale scores	$p = 0.73$
IPIP-R risk-taking scores	$p = 0.47$
Driver confidence scores	$p = 0.24$
Length of licensure	$p = 0.20$

Perception of the UCDS

As part of the MQ, participants were presented with a number of Likert scales pertaining to their perception of the UCDS. The regular and irregular gamers as well as the females non-gamers rated of how they perceived the UCDS. These ratings were analyzed with a one-way between-subjects ANOVA.

UCDS realism. The participants were first asked to rate how realistic they perceived the UCDS to be on a scale of one to seven (one indicated 'not at all realistic' and seven indicated 'very realistic'). The overall mean scores indicated that participant groups found the UCDS to be moderately realistic (M = 4.33, SD =1.15). Further, no group differences were significant (regular male gamers, M = 4.58, SD =1.15; irregular male gamers, M = 4.47, SD =1.00; female non-gamers, M = 3.93, SD =1.28) ($F(2, 43)$ = 1.35, p = 0.27) (Figure 44).This indicated that the three participant groups perception of the UCDS was comparable.

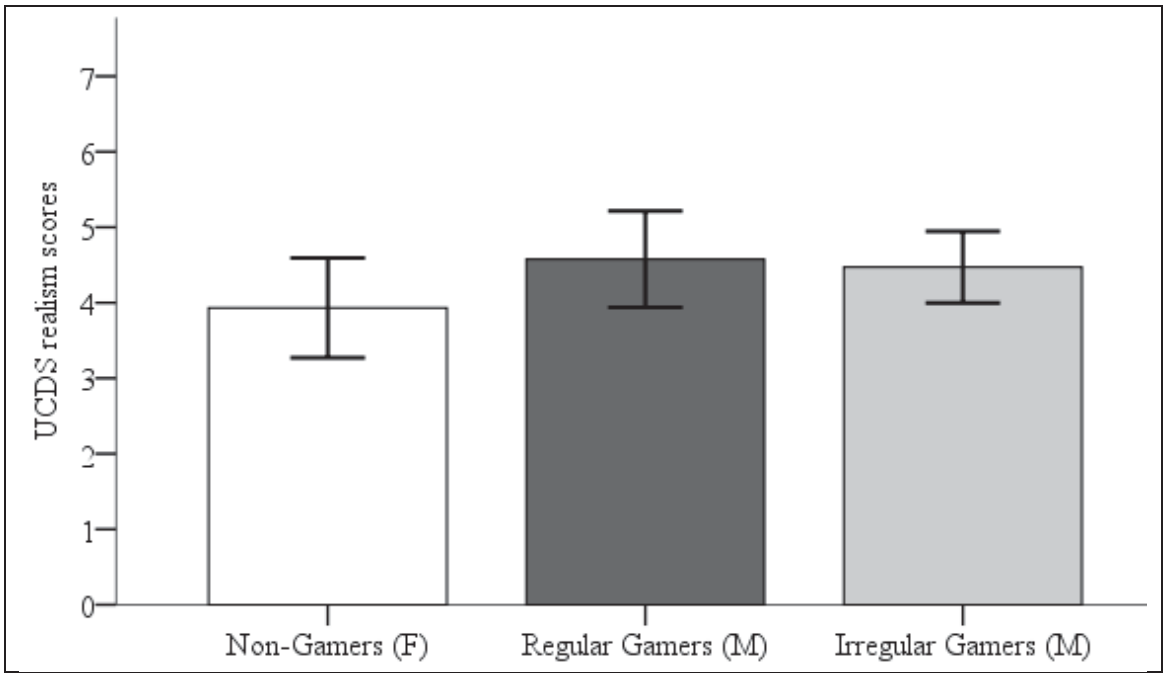

Figure 44. Group ratings on UCDS realism (Error Bars: +/- 2 SE).

Seriously treated the UCDS. The participants were next asked to indicate how seriously they took the driving component in the research session (one indicating 'not at all' and seven indicating 'very seriously'). Overall participants reported that they had taken the scenario seriously (M= 5.91, *SD* =1.0) and there were no significant differences between groups

($F(2,43) = 0.14$, $p = 0.87$). The regular gamers ($M = 5.81$, $SD = 1.25$), irregular gamers ($M = 5.92$, $SD = 0.85$) and female non-gamers ($M = 6.0$, $SD = 0.85$) all reported that they treated the driving portion with similar regard (Figure 45).

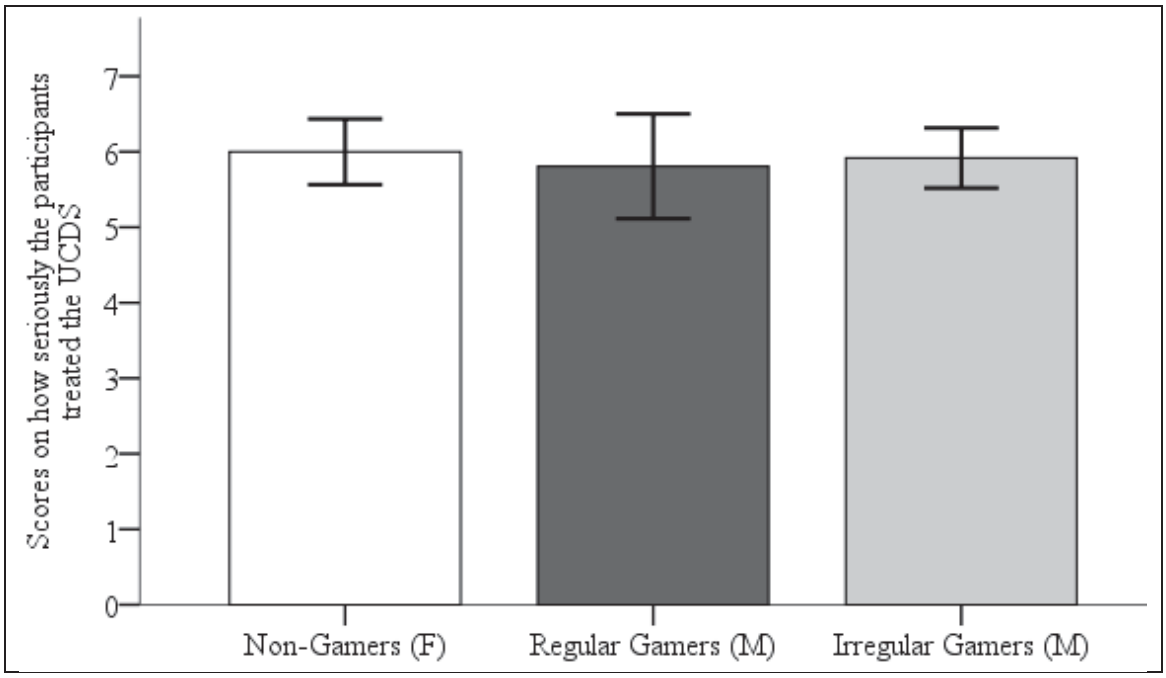

Figure 45. Group ratings on how seriously participants treated the UCDS (Error Bars: +/- 2 SE).

Drove the UCDS like own vehicle. The participants were finally asked to rate how similarly they drove the UCDS to how they would drive their own vehicle (one indicating 'not similar at all' and seven indicating 'very similarly'). The participants indicated that they had driven the UCDS somewhat similarly to their own vehicle overall (M = 5.28, SD =1.23) and again, no group differences were significant ($F(2, 43) = 0.05$, $p = 0.95$). The male regular gamers (M = 5.35, SD =1.18), irregular gamers (M = 5.31, SD =1.13) and female non-gamers (M = 5.20, SD =1.21) all provided very comparable scores (Figure 46).

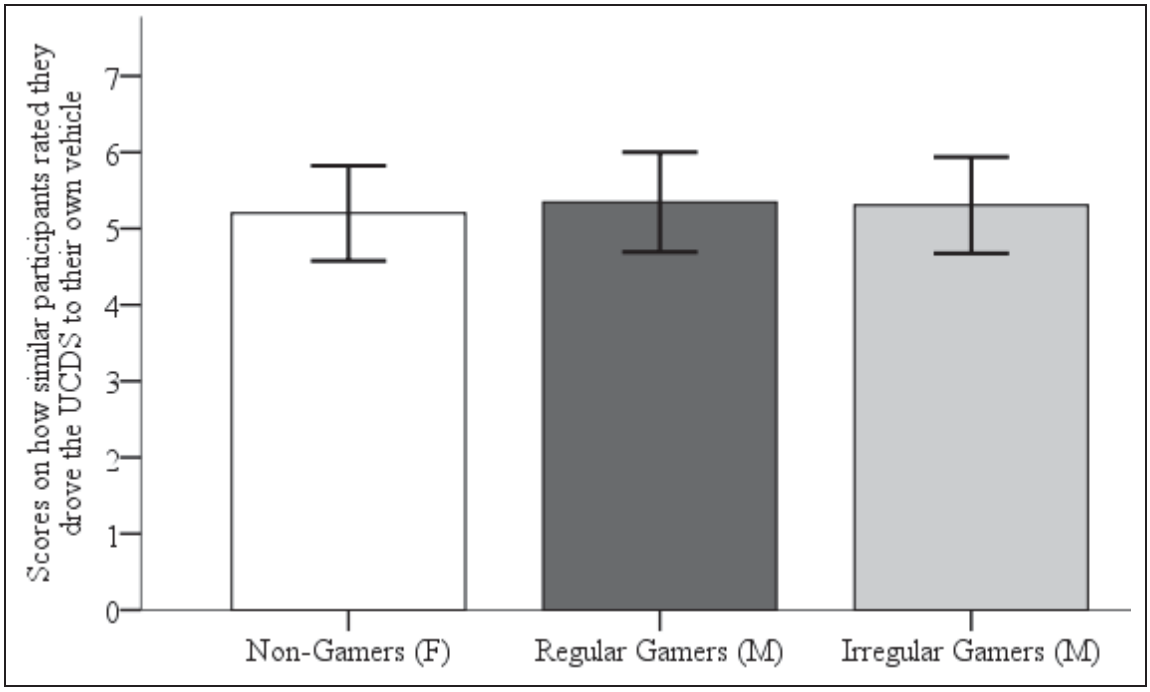

Figure 46. Group mean ratings of how similarly participants drove the UCDS as they would their own vehicle (Error Bars: +/- 2 SE).

Simulator sickness

Over the course of the study, 19 participants (four males and 15 females) experienced simulator sickness during the driving portion of the study and withdrew. Given the large gender discrepancy, the female gender group was analyzed separately to ensure gender did not mask any effects. The sim-sick males were not investigated further as only 11%

of males experienced simulator sickness. . The 21 female participants who did complete all components of the study and the 15 female sim-sick participants were used as an outcome variable in a stepwise-LR analysis to determine whether the variables used in the study were predictive of simulator sickness.

Because this investigation was exploratory, seven variables were entered into the stepwise-LR analyses; the predictor variables (Table 16) and the visual acuity for the participants' left eye, right eye and absolute difference between them. Visual acuity variables were entered after the researcher noticed a pattern when digitizing the questionnaire information and the occurrence of simulator sickness. Visual acuity discrepancy between the participants' eye was expected to be predictive of simulator sickness.

The stepwise-LR was conducted to determine whether instances of simulator sickness for females could be predicted. The outcome variables included 21 viable participants and 15 sim-sick participants; the null model based on these outcomes was able predict group membership with 58% accuracy. Step 0 of the analysis indicated that three variables (sensation seeking scores, visual acuity in the participants' left eye and difference of visual acuity between participants' eyes) were significantly related to the outcome variable (Table 37). Step 1 entered sensation seeking scores into the logistic regression model and significantly improved outcome prediction from the null model ($\chi^2(1, N = 36) = 4.71$, $p = 0.03$). The remaining predictor variables were analyzed to determine whether any accounted for a significant amount of variance once the variance specific to the sensation seeking scores was accounted for. Step 2 entered the visual acuity of participants' left eye and significantly improved upon the null and step 1 model

($\chi^2(1, N = 36) = 4.81$, $p = 0.03$). A test of the full model against the null model was statistically significant, indicating that the inclusion of these two predictors distinguished sim-sick and viable participants ($\chi^2(2, N=36) = 9.52$, $p = 0.01$).

Table 37
Significance of predictor variables at each step of the stepwise-LR for simulator sickness.

Predictor Variable	**Step 0**	**Step 1**	**Step 2**
Sensation seeking scale scores	$p = 0.04$	**Entered**	**Entered**
IPIP-R risk-taking scores	$p = 0.46$	$p = 0.25$	$p = 0.24$
Driver confidence scores	$p = 0.44$	$p = 0.99$	$p = 0.97$
Length of licensure	$p = 0.69$	$p = 0.54$	$p = 0.79$
Visual acuity discrepancy between eyes	$p = 0.045$	$p = 0.06$	$p = 0.17$
Visual acuity - left eye	$p = 0.047$	$p = 0.03$	**Entered**
Visual acuity - right eye	$p = 0.12$	$p = 0.12$	$p = 0.39$

Nagelkerke's r^2 of 0.31 indicated a weak-to-moderate relationship between the predictors and sim-sick outcome. Overall, prediction success was 75% (86% for viable participants and 60% for sim-sick participants); a 17% increase in overall prediction from the null model. The Wald criterion indicated that sensation seeking scores ($\chi^2(1, N=36) = 4.13$, $p = 0.04$) and visual acuity of the left eye ($\chi^2(1, N=36) = 3.89$, $p = 0.05$) made significant contributions to prediction. The EXP(B) value for sensation seeking indicated that when scores on the sensation seeking scale increased by one unit, the odds of being sim-sick decreased 0.30 times. This suggests that as subjective scores on sensation seeking increased the likelihood of experiencing simulator sickness decreased; conversely, as scores on sensation seeking decreased the likelihood of experiencing simulator sickness increased (Figure 47). This would indicate that participants with low sensation seeking scores were more susceptible to simulator sickness and may have had less tolerance for the sensations they experience in the UCDS. EXP(B) for visual acuity of the left eye indicated that as visual acuity increased by 1 unit (become poorer) the odds

of experiencing simulator sickness increased 7.1 times. This indicates that as visual acuity increased (became poorer, e.g. 40/20, 50/20) the odds of experiencing simulator sickness increased; conversely, as visual acuity decreased (became close to 20/20 or better) the likelihood of experiencing simulator sickness decreased (Figure 48).

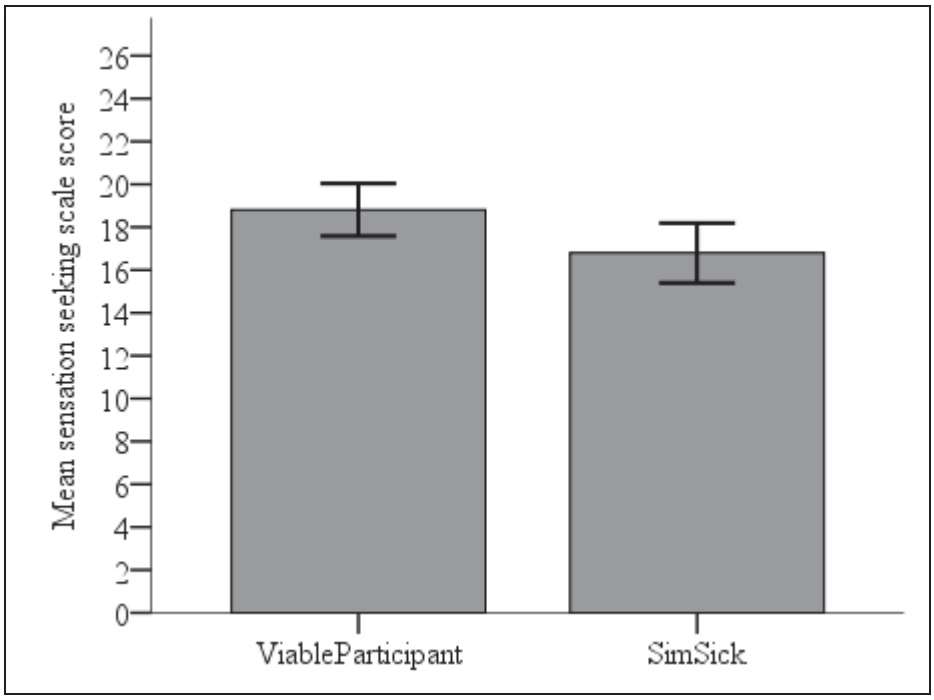

Figure 47. Relationship between sensation seeking scores and simulator sickness among female participants (Error Bars: +/- 2 SE).

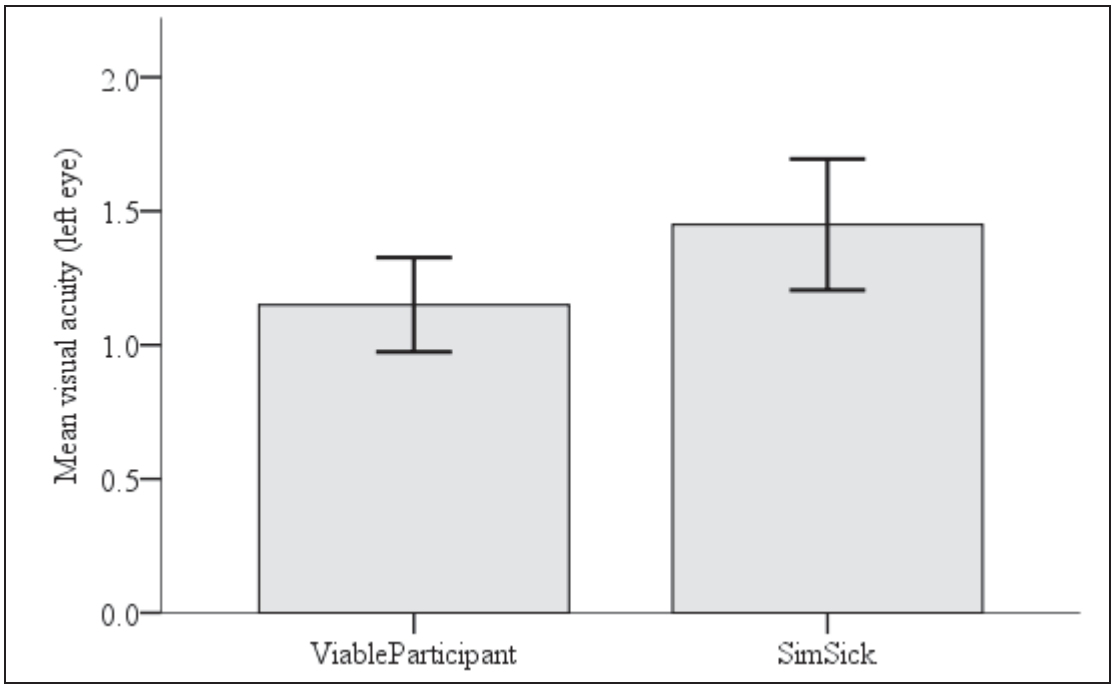

Figure 48. Relationship between visual acuity (left eye) and simulator sickness among female participants (Error Bars: +/- 2 SE).

Discussion

The primary objective of this research was to examine whether video game experience was predictive of high-risk driving behaviour in driving events (late yellow light, left turn across traffic, tailgating and the pull-out car events). Additionally this study sought to determine whether video game experience was related to skills related to handling the UCDS such as speed maintenance, lane positioning and adhering to speed changes. The results that will be discussed in this section will help to describe the observed patterns, trends and relationships in the present study and offer explanations and discussion where these results align or contradict the current literature.

The present study had three main objectives. The first was to establish whether regular and irregular gamers differed on self-reports of their driving history pertaining to the number of vehicular accidents and moving traffic violations they had incurred. The second was to determine whether the regular and irregular gamers adapted to the handling of the UCDS differently and if their perception of the UCDS's fidelity differed. The third and largest objective was to examine whether regular and irregular video game play was predictive of high-risk driving behaviour in a number of simulated driving events. Binary outcomes (stop/go behaviour, waiting/completing a left turn across traffic, safe/unsafe headway time and collision avoidance/collision) were examined with a stepwise-LR analysis to determine whether regular or irregular video game experience was predictive of driving behaviour above and beyond personality variables and driving experience. In addition to the three main objectives, a female-non gamer group was also examined.

This research project also attempted to explore a gap in the literature. There is little research that investigates variations in video game experience. Further, few studies have exclusively investigated personal gaming experience (i.e. video game experience outside of the laboratory context) without the influence of an in laboratory video game condition that might prime participants or result in demand characteristics. Additionally, there are few studies that incorporate a driving simulator (i.e. provide a tangible interface that parallels to on-road driving) to capture participants' driving performance.

Five important findings were learned from the present study and will be discussed in greater detail later in the discussion. These finding are (1) video game experience was actually an extremely poor predictor of high-risk driving behaviour (late yellow light, left turn across traffic, tailgating and the pull-out car events); (2) even when a female non-gamer group was examined, video game experience continued to be a poor predictor of high-risk driving behaviour; (3) the regular and irregular male gamers, and female non-gamers generally adapted and handled the UCDS (speed, speed variance and SDLP) similarly indicating that video game experience was not necessarily an advantage; (4) contrary to previous research, the self-reports of traffic accidents and violations did not differ between regular gamers, irregular gamers and female non-gamers when the relationship between driving history and video game experience was concealed (5) personality traits (specifically low sensation seeking) and poor visual acuity (left eye) are predictive of the simulator sickness for female participants. A summary of all findings are presented in Table 38 and will be explored further in the discussion.

Table 38
Summary of results.

Event/measure	Significance and description
Driving history	**Not significant:** The number of vehicular accidents, at fault accidents in the past 5 years and the total number of moving traffic violations that participants reported were not predictive of group membership (between the regular and irregular gamers as well as the female non-gamers and the collapsed male gamer groups). This suggests that video game play may not be associated with increased traffic collisions or traffic violations.
Between-subject BL measures	
Average speed	**Not significant:** The between-subjects average speed for regular gamers, irregular gamers and female non-gamers were not distinguishable.
Speed variance	**Not significant:** The between-subjects speed variance for regular and irregular gamers did not differ indicated they had similar speed maintenance. **Marginally significant:** Between-subjects speed variance for regular gamers and female non-gamers were marginally significant. The trend indicated that the regular gamers tended to have better speed maintenance than the female non-gamers.
SDLP	**Significant:** Regular gamers had significantly lower scores for SDLP than the irregular gamers which indicated that the regular gamers had greater steering control and kept the UCDS on a more linear vector path. **Practical significance:** The practical significance of this result may be negligible because no participant deviated outside of their lane bound. **Not significant:** The female non-gamers (F) group did not significantly differ from either the male regular or irregular groups.
Within-subject BL measures:	
Average speed **Speed variance** **SDLP**	**Significant:** Within-group differences were observed for all three participant groups across the BL measures (there was 1 exception: the female non-gamers did not have significant within-subject effects for SDLP). Each group exhibited a similar pattern across BL measures which might indicate similar adaptation effects (in the BL measures experienced early in the driving scenario) or a confounding response to road geometry or entities in the virtual environment. The majority of the post-hoc tests indicated that the within-group differences tended to occur between early BL measures (e.g. BL2) and other BL measures.
Reduced speed event	
Between-subject Deceleration rate Speed at the	**Not Significant**: None of the participant groups (regular gamers, irregular gamers and female non-gamers) had significantly different deceleration rates on their approach to the reduced posted speed limit.

new posted speed limit	Similarly their speed once they reached the reduced posted speed limit sign was not significantly different.
Within-subjects Deceleration rate Speed at the new posted speed limit	**Significant**: All three participant groups had significant within-subject effects for deceleration rates across RSE. Post-hoc tests revealed that the deceleration rate at RSE3 was significantly different from RSE1, 2 and 4 for all participant groups. This result was likely due to a spurious effects related to a rogue vehicle that was sometime present in the virtual environment. **Marginally significant:** A marginally significant interaction (gamer type by RSE) for speed at the reduced speed limit approached significance at the fourth instance of the RSE. The regular gamers exhibited an increase in their speed at the reduced speed limit while the irregular gamers exhibited a decrease in speed.
Driving events analyzed with a stepwise-LR	
Late yellow light stop/go	**Not Significant:** Video gamer type (regular, irregular) was not predictive of running late yellow traffic lights, nor were any of the other predictor variables. The majority of participants ran the yellow light. Group membership considering the female non-gamers and collapsed male gamers was also failed to predict stop/go behaviour. Female non-gamers were just as likely as the male gamer groups to run the late yellow light. **Significant / Practical significance:** Driver confidence scores were found to be a significant predictor of stop/go behaviour when the female non-gamer participants were added to the analysis. However the addition of driver confidence scores failed to improve the classification model and was not found to have practical significance.
Left turn event Wait/turn	**Not Significant:** The predictor variables were not found to be predictive of behaviour at the left turn event. Regular gamers were not more likely to turn across traffic than irregular gamers. Further, the collapsed male gamer group was not found to be more likely to turn across traffic than the female non-gamers. The majority of participants chose complete the left turn across traffic.
Tailgate event Safe/unsafe headway time	**Not Significant:** The predictor variables did not predict safe/unsafe headway time. The regular gamers and collapsed gamer groups were not found to follow a slow moving vehicle at significantly greater unsafe headway times than irregular gamers of female non-gamer respectively. While regular gamers were expected to exhibit greater unsafe headway times, the groups were not distinguishable and had a great deal of variability.
Pull-out car Collision avoidance /collision	**Not Significant:** The predictor variables did not statistically predict collision outcome in the sample of regular and irregular gamers. The original hypothesis expected regular gamers to exhibit greater ability to avoid collisions than the irregular gamers.

	Marginal Significance: Group membership (female non-gamer, collapsed male gamer) was marginally significant of predicting collision outcome. The trend indicated that female non-gamers were more likely to collide with the pull-out car than the condensed gamer group.
Pull-out car Safe/unsafe headway time	**Not Significant:** Group membership was not predictive of safe/unsafe headway time following the pull-out car in the stepwise-LR models considering regular and irregular gamers, or the female non-gamers and collapsed male gamers. Driver confidence scores did appear to trend towards significance in the regular and irregular gamer model, but that trend was not found once the female participants were added to the analysis. Regular male gamers were expected to have the greatest rates of unsafe headway time, however the current results indicate that there gamer type was a poor predictor of the outcome variable.
Simulator perception	
Realism Seriousness Like-own-vehicle	**Not significant:** All three participant groups had comparable ratings of the UCDS's realism, how seriously they treated the driving component and how similar they drove the UCDS to their own vehicle. Generally the rating were favourable which suggests that the participant groups did not treat the UCDS and driving environment like a video game and that observed behaviour likely parallels on-road driving.
Simulator Sickness	
Simulator sickness (females)	**Significant:** Sensation seeking scores and visual acuity of a participant's left eye were found to be successful predictors of simulator sickness. Specifically, lower sensation seeking scores and poor visual acuity increased the likelihood that female participants would experience simulator sickness. The inclusion of these two variables significantly increased the classification model that predicted which participants were prone to symptoms of nausea, headache and dizziness in the UCDS.

The lack of significant findings in this study is perhaps more interesting than if there had been statistical evidence to support the hypotheses. In addition, the lack of significant results when female non-gamers were considered raises questions and concerns about the methods used in previous research projects that found significant differences related to video games experience and high-risk driving behaviour. Even driving self-reports of driving history (accidents and violations) failed to demonstrate group differences which is contrary to previous surveys (Fischer et al. 2007; Hardigree

2011). The present study did observe a number of marginally significant trends that suggested personality variables and driving experience had a stronger relationship with the driving behaviour than video game experience. The main driving events will be discussed in further detail.

Baseline (BL) measures

Overall, the lack of significant and practical findings between-group measures of average speed, speed variance and SDLP indicated that the regular and irregular gamers, as well as the female non-gamers, all drove the UCDS in a similar fashion. Thus the results suggest that video game experience was not associated with significantly augmented skills in terms of adapting and handling of the UCDS. The significant within-group effects across the nine BL measures however was not expected and the similar trend exhibited by all three participants groups likely indicates that the BL differences were due to elements in the virtual driving environment than variables related to the participants groups. The majority of significant post-hoc tests were found to occur between BL2 (after the participants experienced their first speed transition from 70 km/h to 50 km/h) and another BL measure. This might suggest the participants were still adjusting to speed maintenance in the UCDS in the first 5 minutes of being in the UCDS. However, some of the significant results may have negligible practical significance; the velocities were consistently within 10 km/h of the posted speed limit and speed variance was typically within 6 km/h. The general propensity for all participants to speed across might related to a belief held by Alberta drivers that reasons that driving within 10 km of the speed will not result in a ticketed violation (even though this assumption is not necessarily true) (TCHIR , 2012). The practical significance of regular gamers exhibiting

lower SDLP than the irregular gamers, might also be negligible because no participant deviated outside of their lane during these BL measures. Curiously, the female non-gamer participants did not differ from either male gamer group.

Reduce speed event (RSE). The focus of this analysis was to determine whether regular gamers were less likely to adhere to posted speed limit changes. The results indicated that deceleration rates and recorded speed at the reduced posted speed limit did not differ between any of the three participant groups. Within-group differences were significant for deceleration rates; post-hoc tests indicated that the deceleration rates at RSE3, differed from the deceleration rates at RSE1 RSE2 and RSE4. A review of the collected video data revealed that a lead vehicle that travelled along the 90 km/h freeway prior to the 'Reduced Speed Ahead' had been programmed to maintain a 150 metre headway distance as to not interact with the participant. However, when this lead vehicle entered the 70 km/h zone it would remained coupled with the participant who was still driving in the 90 km/h zone. The programming to maintain the 150 metre headway distance took precedence over the change of speed zone. This forced the lead the lead vehicle to speed into the 70 km/h zone. It is probable that the presence of a speeding lead vehicle influenced the participants to also speed through the speed transition zone. Haglund and Åberg's (2000) research would support this assertion because they found through collected interviews, questionnaires and highway speed measures that speed choice is largely influenced by the speed of other present drivers. Speed adherence at the reduced posted speed limit also lacked significant group differences. A marginally significant interaction was present at the fourth instance of the RSE; at RSE4 the regular gamers exhibited greater speed at the reduced speed sign (decline in speed adherence)

while the irregular gamers exhibited a lower speed closer to speed limit. It is uncertain why this trend occurred, however one possibility might be that the participants were influenced by previous events in the simulator or were tiring of the experimental session.

Driving events

Late yellow light. Given that a majority of participants ran the yellow light it is likely that the participants did not perceive the late yellow light as being a high-risk event. If running yellow lights was perceived as high-risk, greater stopping rates should have been observed by participants with low IPIP-Risk and SSS scores. Martinez and Porter (2006) have suggested that drivers likely undervalue the risk associated with running a yellow light after they conducted an observational study at eight intersections in Virginia. Their results, which were based on observing 1765 traffic light cycles, indicated that the last driver to enter an intersection would do so while the traffic light was yellow 68% of the time. Previous research has also failed to find group differences between stop/go behaviour (based on age or driver experience) at 2.21 seconds (Caird et al.2007; Milloy, et al., 2010) or even 3 seconds (Andrea, Fildes, & Triggs, 1999; Senserrick et al. 2007). It possible that stopping at these time-to-intersection intervals are perceived as being more high-risk than running the red light since they might put the driver at greater risk for a rear-end collision. Elmitiny et al. (2010) conducted an observational study at a high speed intersection in Florida to examine stop/go decisions. The researchers observed that drivers in a following position in traffic flow are more likely to make ‘go’ decisions to run a yellow light and subsequently increase the risk of a rear-end collision for the lead vehicle.

Left turn event. The overall lack of results in either stepwise-LR analysis (regular and irregular gamers; female non-gamers and collapsed gamers) suggests that the participants did not perceive this event as high-risk. The majority of participants who turned across traffic did so at a relatively safe gap across oncoming traffic flow and were not at risk of a collision. Completing a safe left turn requires drivers to assess multiple sources of information including traffic speed, gap distance/time and road surface condition. The age and sex of the driver may also affect turn decisions (Chovin et al. 1994; Staplin, 1995; Andrea et al., 1999; Chan et al. 2005). Chan et al. (2005) found that 18% of intersection collisions that occurred during a left turn were due to incorrectly judging the speed of oncoming traffic, available time gap and the actual amount of time required to complete the maneouver. The lack of collisions in the present study might indicate that the participants had accurately judged and assessed whether they could safely complete the left turn. There is also debate about gender effects of gap acceptance; some research suggests that males accept shorter time gaps (Wennell & Cooper, 1981; McDowell et al., 1983; Yan, Radwan & Yongna 2007) while others have found no gender difference (Cooper & Zheng, 2002). The present study did not find significant differences between males and females for gap acceptance.

The design of the left turn scenario may have biased participants to wait for longer time gaps. For example, at the start of a left turn event, the participant would approach a red light at an intersection and come to a stop, as opposed to already being in motion. This starting position likely put the participant at a disadvantage because the participant would be aware that they would need to choose a time gap that would allow them to build momentum. The time gaps presented between the oncoming traffic

increased by 0.5 seconds in a linear fashion until an appropriate gap size could be selected. Cooper and Zheng's (2002) research found that the longer drivers had to wait to complete a left turn across traffic, the less likely they were to choose a subsequent gap between vehicles (i.e. participants would be more willing to wait until no oncoming traffic was present). In the present study, the initial gap encountered between oncoming traffic had the highest risk and decreased thereafter. This might have influenced participants to wait longer before initiating the left turn. Participants could simply adopt a strategy of waiting for less risky gaps instead of evaluating each gap. Future research might consider randomizing the presentation of time gaps so they are not predictable and that participants do not have to wait for 4 vehicles to pass through the intersection before a safer gap becomes available.

Tailgate event. Brackstone and McDonald (1999) explained that a safe headway / following distance should allow a driver the ability to brake or allow for an intervention in the event that the lead vehicle stops unexpectedly. Shorter headway times then result in short 'time to collision' by default. Alberta Transportation and driver education programs teach that drivers should maintain at least 2 seconds of headway distance between vehicles (Government of Alberta, 2007). Brackstone and McDonald (1999) argue that the '2 second rule' for headway time may be too conservative compared to other headway heuristics that many drivers use, though most are simply anecdotal.

Extending the idea that the 2-second rule may be overly conservative, it is possible that the risk perception associated with the present study's tailgating event with the slow moving vehicle was low. If participants maintained 2 seconds of headway distance at 35 km/h that would equate to a minimum headway distance of 19.44 metres.

Urban traffic is typically more congested than what was presented in the virtual environment. For example, had there been vehicles following behind the participant and clearly visible in the rear view mirror, participant may have adopted shorter headways and perhaps felt a pressure to follow closer.

Brackstone and McDonald (2002) also explain that drivers tend to adopt a pattern of speeding up and slowing down behind a lead vehicle ('spiralling'), although whether this is an unsafe or high-risk behaviour has not been explained. While the present study only categorized mean headway times as being safe or unsafe, it may be worthwhile for researchers to develop clear guidelines as to what should be considered safe or unsafe following distance/times at different speeds. Currently the body of literature tends to focus on headway times at speeds higher than 35 km/h.

Pull-out car event. Driving experience (length of licensure) was determined to be a significant predictor of collision outcome. Specifically, participants with more driving experience had somewhat greater success at avoiding collisions. However, despite the statistical significance of the length of licensure variable, it did not have practical application as it did not improve the classification model.

The lack of practical results with the pull-car event was surprising when considering that many video game studies indicate that gamers have cognitive gains in visual search, attention, response time, temporal judgments and visual motor skills (Green & Bavelier 2003; Bialystok, 2006; West et al. 2008; Chisholm et al. 2010; Donohue, Woldorff & Mitroff, 2010; Granek et al.,2010; Green, Pouget & Bavelier, 2010). However many of these laboratory studies allow participants to be more vigilant in a single laboratory task. In contrast, driving requires more complex attention to various

information inputs and ability to ignore numerous distractions while controlling their vehicle under rapidly changing road geometries. For example, when video game experience is tested with the WRBTV hazard scenarios (Fischer et al. 2007; Fischer et al. 2009), participants only had to press a single button. Participants did not have control a vehicle's speed, position a vehicle within a lane or other maneuver through intersections and turns. In this study's analysis, collision rates with the pull-out car indicated that the initial speed of the participants was the highest predictor of collision outcome. Obviously manual control of the UCDS car is substantially more demanding than a push-button response.

Once the pull-out car entered the roadway in a scenario, it continued to travel along the roadway at 35 km/h. Creaser (2003) reported that after participants experienced an error behind a lead vehicle that braked, participants would increase their headway for a limited time. However, compared the previous tailgate event, more participants exhibited unsafe headway times (less than 2 seconds) after the pull-out car's collision event. It possible that the shorter headway times were due to the participants being closer to the pull-out car initially when it rejoined the roadway compared to the first tailgate event.

Summary. Overall, there are a number of reasons why video gamer categorization failed to generate significant results. The group sample sizes were low, however, the significance levels for video gamer type was particularly low. This may suggest that video game experience would fail to produce significant result even if the sample sizes were increased. The personality and driving experience predictor variables that did trend towards significance would be better candidates for future investigations.

Driving experience and the age-range of the participant group may also offer an explanation to the lack of significant results. All participants in the present had at least a full year of driving experience and which might indicate that high-risk task performance exhibited in previous research might actually be a product of driver inexperience. For example, poor driving performance related to steering and speed control has consistently been found to be related to lack of driving experience (Kimball, Ellingstad & Hagen, 1971; Shinar & McDonald, 1978; Blaauw,1982; Martinez & Porter, 2006). Additionally, the present study offered an ideal driving environment; participants did not have their attention diverted away from the driving task (e.g. cell phones, conversations with additional passengers or researcher, or in vehicle devices such as a radio or GPS). Ranney et al. (2000) suggests that as driving experience is gained, less mental resources are required which allows drivers to engage in other mental activities without driving detriments.

However, these possibilities do not explain why previous research did find significant results high-risk driving behaviour. Boot, Blakely and Simons (2011) call into question whether previous research using cross-sectional gamer/non-gamer groups produce results that are confounded with demand characteristics, biased recruitment strategies and placebo effects. Boot et al.'s (2011) review specifically calls into question whether reported perceptual and cognitive gains of participants with video game experience or trained to play a video game are actually the result of a confounding variable. Boot et al. (2011) reported four main criticisms in a review of 17 cross-sectional studies that had observable gamer/non-gamer differences: overt recruiting (possible differential demand characteristics), unspecified recruiting methods, potential third-

variable, no test of perceived similarity of task and gaming experience. Langer et al. (2010) also argues that the confounding nature of differential demand characteristics explains that individuals recruited on the basis of their video game experience might behave according to their expectation of the researcher's hypotheses as opposed to how they would actually behave. The Boots et al.'s (2011) review also mentions that participants, particularly video gamers, might perceive the cross-sectional research as a competitive contest which influences gamers to perform at their peak performance. This is important because the element of competition may have motivated the participant gamers to perform at their peak ability.

While Boot et al.'s (2011) criticisms are specific to research investigating general perceptual and cognitive gains, the same criticisms can be extended to previous research investigating video games and high-risk driving behaviour. For example, the Fischer et al. (2007) and Fischer et al. (2009) studies asked participants about their video game experience during the recruitment process or before encountering the experimental condition. Further, Fischer et al.'s (2009) study may have biased participants by establishing the research environment as a place of 'play' (encoding specificity principle) by recruiting participants by asking if they were "willing to participate in a study on testing computer games" (p. 1400). The participants in these studies that were presented with the WRBTV might have treated the scenarios with an element of 'play' (e.g., in the oncoming traffic scenario in which a head on collision would likely be occur without a driver intervention, the participants might have treated the scenario more like a 'game of chicken'). These effects were likely exacerbated by some of the time delays between conditions; for instance, Fischer et al. (2009) conducted an experiment that only had a 15-

minute time delay between the racing video game and the WRBTV risk assessment. Additionally the overt recruiting tactics and possible priming effects of the video game condition possible lead the participants to infer the research hypotheses and behave 'riskier' and in accordance with the perceived expectation.

The current study attempted to prevent demand characteristics and encoding specificity effects by covertly screening for video game experience using a battery of questions on the SONA system. The participants would have answered a pre-screen question related to their video game experience at least a month before their participation. While this method of screening had its additional issues, it did recruit participants with video game experience in a way that they did not associate video games with the research scenario. Questions about participant gaming history were not answered until after completing the driving portion of the study. If the present study generated differential expectations, these may have been due to participants who believed that they were good drivers rather than expecting their video game experience to influence the outcome. Participants would undoubtedly infer that their driving behaviour was under investigation, additionally the presence of video cameras in the vehicle were a reminder that they were being observed. By this reasoning, there is the possibility that participants experienced the observer effect (where the participant modifies behaviour in response to being observed, (Kazdin, 1982)) and performed on their best behaviour in the driving scenario. However, the majority of participants reported favorable scores that they treated the UCDS similar to their own vehicle. Further a number of the variables, particularly the BL measures were collected in a subtle manner that the participant likely did not infer.

Evans (2004) is a strong critic of driving simulation and has suggested that within the laboratory setting, only peak performance (i.e. what the driver can do) can be accurately measured. While the Fischer (2007; 2009) studies did not use a driving simulator, it would be logical to expect that participants on the WRBTV hazard perception test would display their top performance. However, the results from the Fischer (2007; 2009) studies indicated that drivers' risk-taking driving behaviour was influenced by racing video games. The results from the present study are contrary to the Fischer (2007; 2009) studies. A difference between the studies is that the Fischer (2007; 2009) studies specifically investigated racing related video games, while the present study sought to determine whether actual video game play and experience influenced driving behaviour. The present study may have been more aligned with the GAM model than the altered risk-taking model applied by Fischer (2007; 2009) because the majority of video games reported by participants in the present study included violent genres rather than risk-promoting racing video games.

Limitations

Sample size was the main limitation of the present research. Group categorization lead to smaller sample sizes based on video game experience. While the researcher was aware of that sample sizes were small once the analysis was started, there was no opportunity to recruit additional participants because the UCDS experienced hardware failure of once of its essential components and was no longer operational

In addition, some of the hypotheses were related to reaction time to and the participants' ability to perceive and respond to events. However during the analysis it became unclear if the participants' even recognized some of the cues in the virtual world,

particularly the late yellow light event. Eye tracking was not used in this study to determine precisely where participants were looked while scanning the virtual environment effectively. In retrospect, eye tracking might have been useful during the pilot stage of this study to determine whether all elements presented in the virtual world were noticeable.

The participants' subjective reports of video game experience do not seem to be entirely trustworthy. The goal of the study was to determine whether the participants' previous video game experience was related to their driving behaviour. However there is possibility that many participants over-reported or under-reported their video game play. It is possible that the irregular gamers were once regular gamers before entrance into university and that their reduced and sporadic video game play is a recent trend for them. In other words, regular and irregular gamers may belong to a single group that is historically affected by academic demands.

Finally, the debate of simulator validity specific to driving perforce and behaviour has to be addressed. Driving performance has been described as a driver's knowledge, skill, perceptual and cognitive ability as they relate to driving, while driving behaviour describes how the driver actually utilizes their skills (Evans, 2004). Evans (2004) further suggests that only driving performance can be investigated with driving simulation. By this understanding, it's possible that the behaviour in the present study was an example of the participants' best driving performance (i.e. what the drivers can do versus what they actually do). However, some of the patterns of driving behaviour seen in this study did reflect results from naturalistic observations previously discussed. It may be that the results in the present study represent 'relative validity' in that the mirror trends in 'real

world' driving but may not represent 'absolute validity' (Caird & Horrey, 2011). Additionally, the were variable outcomes in the study that did reflect high-risk behaviour, however, these behaviours were simply not predicted by video game experience, personality traits or experience which may imply that another variable may be underlying.

Future research

Video games are becoming increasingly more pervasive in North America and gamer demographics are changing. Many people might stereotypically think of gamers as being teenage boys, but the mean age of gamers is now 35 and females gamers now account for approximately 40% of the video game consumer market (ESA, 2011). Future research investigating video games should consider targeting this changing demographic. That said, the lack of meaningful results in the present study suggests that video game experience has a weak relationship with driving performance. A meta-analysis by Ferguson and Kilburn (2009) suggests that there is a publication bias in the literature in favour of results of results that connect violent media to aggressive behaviour. Contrary to popular research, Ferguson and Kilburn's (2009) meta-analysis found that when effect sizes are adjusted to account for the existing publication bias, the overall effect of violent media on aggressive behaviour was negligible (r = 0.08). Rather than investigating video games, researchers may want to focus research efforts on other variables that might have a greater relationship with driving behaviour.

This study was one of the first to systematically examine driving performance of participants with variable gaming experience in a moderate fidelity simulator with scenarios that focused on specific risk-taking and driving performance skill acquisition.

Previous research has used in-laboratory video game conditions and overt recruiting technique that would “tip-off” potential participants about the research hypotheses. Additional research that investigates gamers in a more realistic driving context to prevent demand characteristics and priming effects should be carried out to determine whether the findings of the present study or previous studies have replicable results. Research laboratories that have already conducted research with an in-laboratory video game condition might consider replicating their studies after removing their video game component and then having the participants report their video game experience after the experimental conditions are completed.

Future research projects should also investigate participants’ risk assessment of the driving events presented in the research scenarios. Finally, other measures such as eye movements and manipulations such as more complex driving environments including distractions (i.e. mobile phone, passengers, in-vehicle device) and varied road conditions should be investigated.

Conclusion

Video games are still a “hot topic” in media and news reports whenever a deviant behaviour occurs that may be attributed thusly. However, video games are fairly endemic to North American households. Many of the research projects investigating video games might be biasing their outcomes from overt recruiting, unintentionally provoking demand characteristics or changing the perception of the laboratory context by prefacing the serious aspects of the research with video game play. The results of the present study suggest that when the priming condition is removed from the research session and

participants are able to exhibit their driving behaviour in a more tangible driving context they are not at greater risk than other participant groups.

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Appendix A

INFORMED CONSENT

TITLE OF INVESTIGATION: How does media affect driving behaviour?

STUDY SPONSOR AND INVESTIGATORS:

Aimée Pearson, MSc Student CERL University of Calgary ampearso@ucalgary.ca	Dr. Jeff Caird, Professor CERL University of Calgary jkcaird@ucalgary.ca
Kate Johnston, MSc Student CERL University of Calgary kate.johnston@ucalgary.ca	Matthew Wilkins, Undergraduate Student CERL University of Calgary mswilkin@ucalgary.ca

Additional researchers associated with the Cognitive Ergonomics Research Laboratory (CERL) under the supervision of Dr. Jeff Caird may have access to the data collected from this study for future analyses. All collected information will remain confidential and secure in the CERL laboratory.

The study is being conducted for Aimee Pearson's Master's thesis and the collected data will be presented in the researcher's final thesis. Auto21, a Canadian research and development community is a sponsor of this research project.

INTRODUCTION

This consent form, a signed copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more details about something mentioned here, or information not included here, please ask. Please take the time to read this form carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

STUDY PURPOSE

This study will investigate how different forms of media affect driving behaviour.

Time & Compensation for Participation

This study should take between 60 to 90 minutes to complete. Your participation will be compensated up to 2% worth of course credit (you gain 0.5% of course credit for each half hour of participation). If you withdraw early from the study, you will be compensated course credit rounding up to each 30 minute time segment you stayed in the study.

STUDY PROCEDURES

In this session, you will be asked to fill out several questionnaires regarding items such as demographics, likelihood of experiencing simulator sickness, personality traits and typical driving behaviours, and have several aspects of your vision tested. You will have to provide proof of a valid driver's license; however we will not require a copy of it for our records.

A minimum of 20/50 vision acuity level (the legal minimum requirement to drive in Alberta) is required to continue in this study. Ishihara colour test plates will also be used to assess your colour vision. Persons with a colour deficiency will be ineligible to continue with the study for the purpose of keeping our participant sample homogenous on vision variables. These vision tests are not diagnostic in nature, however if you have any concerns about your vision we recommend participants seek a professional optometrist or ophthalmogist.

You will get a chance to do a 7 minute practice drive in the driving simulator to determine if you are susceptible to simulator sickness. The practice drive will be followed by 2 experimental drives in the University of Calgary Driving Simulator.

Approximately 15% of participants experience simulator sickness. You may choose to withdraw from the study at any time and will still receive partial credit for your participation. Information collected up to the point of your withdrawal will still be used for analysis.

The 2 experimental drives should take about 15 minutes each and will examine driving performance. We will be measuring how well you control the vehicle and your reaction time to hazards in a variety of industrial, urban, suburban, freeway, and rural driving scenarios. Furthermore, upon your consent you may be asked to wear a device on your head that will monitor your eye movements while you are driving the simulator. After the experimental driving sessions are finished, you will be asked to complete a couple more questionnaires.

Information collected on each participant will be assigned a random participant number to ensure confidentiality. All data reduction and analyses will be conducted using this number. Results will be aggregated, compared and reported as groups. Only experimenters specifically involved with this project will be allowed access to the data. Data is stored for a period of five years in locked filing cabinets, after which it is destroyed.

POSSIBLE BENEFITS OF BEING IN THE STUDY

Participation of this study will benefit you in the form of course credit. Your performance data will be of scientific interest and add to the researcher's understanding of the relationship between media and driving.

POSSIBLE RISKS AND DISCOMFORTS OF PARTICIPATION

1. Simulator Sickness

A small percentage of individuals (approximately 5-15%) experience discomfort while driving in the simulator. Discomfort may result due to a mismatch between what you see and what you feel in the simulator. Temporary symptoms of discomfort can include eyestrain, blurred vision, difficulty in focusing, difficulty concentrating, confusion, apathy, and nausea. Drowsiness, fatigue or headache may also occur.

If you experience discomfort while driving, you will be able to end the simulation at any time either by asking the researcher to stop the simulation or by stopping the vehicle and getting out of the car. The researcher will also monitor you for symptoms and will stop the simulation if they feel it necessary. Should you feel any discomfort, we request that you rest in the lab for about 20 minutes before you leave. Should you decide not to participate because you are at risk for simulator sickness or discontinue the study because you feel unwell, you will still receive partial credit for the session.

There has not been sufficient research to understand how your experience in the driving simulator carries over to driving your own vehicle. This is called *negative transfer* and based on research experience gained in this lab and by others; we consider it to be a minimal risk. To be

on the safe side, we recommend that participants wait 20 minutes after testing is complete before driving a vehicle. To fill the time, we will ask you to fill in a questionnaire on driving habits and will provide you with a detailed explanation of the purpose of the study and answer any questions you may have.

2. **Discomfort from Eye Movement Camera**

You may experience pressure or discomfort due to the head-band of the eye movement system. In rare instances, these pressure points may lead to mild pressure headaches that disappear after removal of the equipment. An equipment fitting will occur prior to the simulator session to ensure that the equipment will fit and will not cause undue discomfort during the test drive. Head movement may be slightly restricted due to the electrical cords running from the in-car instrumentation to the headgear. You will be given a number of breaks between each drive when you can take off the eye movement system and relax.

PARTICIPANT RESPONSIBILITIES

I understand that I am to:

- Give correct information about my driving history over the past 5 years and my age.
- Co-operate with study procedures and perform the session to the best of my ability.

PARTICIPANT RIGHTS

I understand the following are my rights:

- My participation is entirely voluntary and I am free to discontinue the study at any time and for any reason.
- I can ask questions about my participation at any time in the study before or after I sign this agreement
- I can be asked to leave the study if the researcher believes it is in my best interest, or if I fail to cooperate with requirements and procedures
- My name will appear only in restricted confidential files, stored in a locked file at the University of Calgary and a participant number will be used for all other purposes, including all reports and publications. No raw data will be given to the Insurance Bureau of Canada.
- My identity will not be revealed unless mandated by law. However, recordings of my eyes, face, hands, and feet will be seen by researchers directly involved with the project.
- I will receive a signed copy of this consent form.

Appendix A

Signature/Written Consent

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate as a research subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

I, _____, have read this informed consent and I understand its contents. My participation in the research study is entirely voluntary.

Participant's Signature _____Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____**Date:** _____

Optional Consent to use video-taped footage:

I, _____, ☐ Agree ☐ Do Not Agree
to allow the investigators in this laboratory to use video tape of my eyes, face, hands and feet in articles or presentations. You will be clearly identifiable in any video footage or screen captures we may present. Please note that, where intended reporting of photographed or videotaped images includes public display, the researchers will have no control over any future use by others who may copy the images and repost them in different formats or contexts, including online.

_____	_____	_____
Participant Name	**Signature**	**Date**

Questions/Concerns

If you have any questions about your participation in this study, you can contact:

Aimée Pearson, MSc Student
CERL, Department of Psychology
University of Calgary
ampearso@ucalgary.ca

Dr. Jeff Caird, Professor
CERL, Department of Psychology
University of Calgary
jkcaird@ucalgary.ca

If you have any concerns about the way you have been treated as a participant, please contact the Senior Ethics Resource Officer, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

Appendix B

Simulator Sickness Questionnaire

Instructions: The purpose of this questionnaire is to determine if you are likely to become ill while driving the simulator. If you respond yes to any of these questions, you will be encouraged not to participate in the study. You will still receive your bonus credits.

Please respond by selecting either Yes or No.

1. Do you have any health problems that affect your driving? ☐ Yes ☐ No
If yes, what? _____

2. Do you experience inner ear problems, dizziness, vertigo, or balance problems?

☐ Yes ☐ No

3. Do you have any history of motion sickness? (e.g., have you ever felt nauseated or physically uncomfortable while in a car or on a boat; do you feel sick if you try to read a book in a moving vehicle?)

☐ Yes ☐ No

4. Do you or have you had a history of claustrophobia? ☐ Yes ☐ No

5. Are you suffering from any lingering effects of stroke, tumor, head trauma, or infection?

☐ Yes ☐ No

6. Do you or have you ever suffered from epileptic seizures? ☐ Yes ☐ No

7. Is there any possibility you are pregnant? ☐ Yes ☐ No

8. Do you or have you had a history of migraine headaches? ☐ Yes ☐ No

9. Are you currently taking any prescribed medications? ☐ Yes ☐ No

10. If so, do any of the medications you are taking affect your vision, or make you feel dizzy or nauseated?

☐ Yes ☐ No

Appendix C

Participant # _____

UNIVERSITY OF CALGARY

Driver Experience Questionnaire

Instructions: The purpose of this questionnaire is to assess your driving experience and general background. Your personal identity will not be associated with any of your responses. As before, only a unique number will be recorded and will be used by the researchers.

Part I. Demographic Information

1. Are you? ☐ Male ☐ Female
2. Age:_____
3. Date of birth (YY/MM/DD): _____
4. Are you the first born, middle or youngest child in your family? _____
5. Number of years of education: Primary-High School: _____(years)

   Post-Secondary:_____(years)
6. Are you right-handed or left-handed? Right ☐ Left ☐

Part II. Driving Experience

7. Do you have a valid driver's license? Yes ☐ No ☐
8. What class of license do you have? _____ (e.g. class 5, class 3)
9. Do you have a learner's license? Yes ☐ No ☐
10. How many years/months have you had a driver's/learner's license? _____ year(s)/month(s)
11. How old were you when you first obtained a probationary driver license? _____
12. On average, how many kilometers do you drive:
    Per week? _____ km/week (e.g. 950 km/week)
    Per month? _____ km/month (e.g. 4000 km/month)
    Per year? _____ km/year (e.g. 50 000 km/year)
13. On average, how many hours would spend driving:
    Per week? _____ hours/week (e.g. 20 hours/week)
    Per month? _____ hours/month (e.g. 100 hours/month)
14. On average, how many times a week do you drive with a friend in the car? _____

Please Continue to Next Page

15. How many accidents as a driver (including fender benders) have you had in the last 5 years? _____
    Of these, how many were considered your fault? _____
    How many were considered the other driver's fault? _____

16. How many accidents as a driver (including fender benders) have you had in your life?
    Of these, how many were considered your fault? _____
    How many were considered the other driver's fault? _____

17. How many accidents have you been involved in as a passenger or pedestrian? _____

18. If any of the accidents were considered your fault, list what type of accident it was? (e.g., roll over, rear-end collision, failure to give right of way)
    Note: If more than one, please list the type of accident each one was
    _____
    _____

19. Do you usually wear a seatbelt while driving?
    a) Always
    b) Most of the time
    c) Half of the time
    d) Some of the time
    e) Never

20. Do you usually drive a(n): ☐ Automatic ☐ Standard

21. How many moving violations have you had in the past 5 years? _____
    (E.g., speeding tickets including multi-nova, reckless driving, violating a stop sign or light. Do **not** include parking tickets.)

    Please list each type of violation (e.g., speeding) and the number of tickets you have had for that type (e.g., 2) in the past 2 years.
    a)_____
    b)_____
    c)_____

22. Did you take a Driver's Education Course when you were learning how to drive? Yes ☐ No ☐

23. Where did you take the course/through what agency? _____

24. Have you had previous experience in the driving simulator? ☐ Yes ☐ No
    If yes: please describe. _____

Please Continue to Next Page

Part III. Medical Information

25. Have you been hospitalized during the past year for a serious medical condition or illness (for example depression, Parkinson's disease, etc.)?

☐ Yes ☐ No

If yes, please explain_____

_____

26. Are you currently under a doctor's care for a serious medical illness or condition (for example, stroke, pneumonia, bypass surgery, etc.)?

☐ Yes ☐ No

If yes, please explain_____

_____

_____

27. Are you regularly taking any prescribed medications? ☐ Yes ☐ No

If yes, please provide a name and indicate what the medication is used for:

Name of Medication	Purpose

28. If yes, have you noticed any of the following side effects (check all that apply)?

☐ Drowsiness
☐ Dizziness/Disorientation
☐ Memory problems
☐ Aches/Pains
☐ Uncontrolled movements
☐ Speech problems
☐ Vision problems
☐ Mood problems
☐ Attention problems
☐ Other:_____
☐ Other:_____
☐ Other:_____

Please Continue to Next Page

Participant # _____

29. Have you taken any medication today? ☐ Yes ☐ No

If yes, what medication have you taken: _____

30. Do you have any visual diseases or other diseases that degrade your vision? ☐ Yes ☐ No

If yes, please specify each: _____

_____

_____

31. Please rate your physical health relative to others your age on a scale from 1 to 5 (circle one).

1	**2**	**3**	**4**	**5**
Very Poor	**Poor**	**Average**	**Good**	**Excellent**

32. Do you use glasses (or contact lenses) for distance? ☐ Yes ☐ No

33. Do you use glasses (or contact lenses) for reading? ☐ Yes ☐ No

34. Do you use bifocals, trifocals or progressive lenses? ☐ Yes ☐ No

If yes, please specify which of the above you require: _____

35. Do you have any hearing impairments? ☐ Yes ☐ No

If yes, please specify _____

Thank you for filling out this questionnaire

For Office Use Only

Visual Acuity: **Left Eye 20/_____**

Right Eye 20/____

Contrast Sensitivity: **A___ B___ C___ D___ E___**

Color Vision: **Trichromat _____ Dichromat _____ Monochromat_____**

Appendix D

Sensation Seeking Scale

Instructions. Please indicate whether you agree or disagree with the following statements.

	Agree	Disagree
1. I like wild "uninhibited" parties.	☐	☐
2. I can't stand watching a movie that I've seen before.	☐	☐
3. I often wish I could be a mountain climber.	☐	☐
4. I like some of the earthly body smells.	☐	☐
5. I get bored seeing the same old faces.	☐	☐
6. I like to explore a strange city or section of town myself, even if it means getting lost.	☐	☐
7. When you can predict almost everything a person will do and say, he or she must be a bore.	☐	☐
8. I usually don't enjoy a movie or a play where I can predict what will happen in advance.	☐	☐
9. I have tried marijuana or would like to.	☐	☐
10. I would like to try some of the new drugs that produce hallucinations.	☐	☐
11. I sometimes like to do things that are a little frightening.	☐	☐
12. I enjoy the company of real "swingers."	☐	☐
13. I often like to get high (drinking liquor or smoking marijuana).	☐	☐
14. I like to try new foods that I have never tasted before.	☐	☐
15. Looking at someone's home movies or travel slides bores me tremendously.	☐	☐
16. I would like to take up the sport of water skiing.	☐	☐

	Agree	Disagree
17. I would like to try surfboard riding.	☐	☐
18. I would like to take off on a trip with no preplanned or definite routes or timetables.	☐	☐
19. I would like to make friends in some of the “far-out” groups like artists or “hippies.”	☐	☐
20. I would like to learn to fly an airplane.	☐	☐
21. I would like to go scuba diving.	☐	☐
22. I would like to meet some persons who are homosexual (men or women).	☐	☐
23. I would like to try parachute jumping.	☐	☐
24. I prefer friends who are exciting and unpredictable.	☐	☐
25. I like to have new and exciting experiences and sensations even if they are a little unconventional or illegal.	☐	☐
26. I often find beauty in the “clashing” colours and irregular form of modern painting.	☐	☐
27. I would like to dive off the high board.	☐	☐
28. I get very restless if I have to stay around home for any length of time.	☐	☐
29. I like to date members of the opposite sex who are physically exciting.	☐	☐
30. Keeping the drinks full is the key to a good party.	☐	☐
31. The worst social sin is to be a bore.	☐	☐
32. A person should have considerable sexual experience before marriage.	☐	☐
33. I could conceive of myself seeking pleasures around the world with the “jet set.”	☐	☐

	Agree	**Disagree**
34. I like people who are sharp and witty even if they do sometimes insult others.	☐	☐
35. I enjoy watching many of the “sexy” scenes in movies.	☐	☐
36. I feel best after taking a couple of drinks.	☐	☐
37. People should dress in individual ways even if the effects are sometimes strange.	☐	☐
38. I would like to sail a long distance in a small but sea-worthy sailing craft.	☐	☐
39. I have no patience with dull or boring persons.	☐	☐
40. I think I would enjoy the sensations of skiing very fast down a high mountain slope.	☐	☐

Thank you for filling in this questionnaire!

Appendix E

International Personality Item Pool (IPIP) sub-scale for Risk Taking					
	Please indicate by circling your agreement or disagreement with the below statements on a scale from **1 – strongly disagree** to **5 –strongly agree.**				
	Strongly Disagree				*Strongly Agree*
Enjoy being reckless.	1	2	3	4	5
Would never go hang-gliding or bungee-jumping.	1	2	3	4	5
Take risks.	1	2	3	4	5
Stick to the rules.	1	2	3	4	5
Seek danger.	1	2	3	4	5
Would never make a high risk investment.	1	2	3	4	5
Know how to get around the rules.	1	2	3	4	5
Am willing to try anything once.	1	2	3	4	5
Seek adventure.	1	2	3	4	5
Avoid dangerous situations.	1	2	3	4	5

Appendix F

Driver Confidence Questionnaire

Instructions: Please indicate how much you agree or disagree with the following statements, where 1 = Strongly Disagree and 7 = Strongly Agree.

	Strongly Disagree						Strongly Agree
1. I am a better driver than others my age.	1	2	3	4	5	6	7
2. I am a better driver than most drivers.	1	2	3	4	5	6	7
3. Older drivers are a real problem on the road.	1	2	3	4	5	6	7
4. Other drivers are usually courteous.	1	2	3	4	5	6	7
5. Driver training is a waste of time.	1	2	3	4	5	6	7
6. I still could use more training.	1	2	3	4	5	6	7
7. It is likely that one day I will have a crash.	1	2	3	4	5	6	7
8. I am uncomfortable driving close behind another car.	1	2	3	4	5	6	7
9. I sometimes drive at a speed below the limit.	1	2	3	4	5	6	7
10. Speeding is always wrong.	1	2	3	4	5	6	7
11. Driving at the speed limit is always safe.	1	2	3	4	5	6	7
12. Driving drunk is always wrong.	1	2	3	4	5	6	7
13. I am confident in my driving ability.	1	2	3	4	5	6	7
14. I am confident in my ability to manage possible hazards when driving.	1	2	3	4	5	6	7

Driving Behaviour Questionnaire

Please answer all the questions in the pages that follow. The words that are used to describe how often you may engage in the various driving behaviours are defined next. If you do the action that is described in a particular question almost all of the time that you encounter that situation, then you should choose Very Often. If you do the action that is described most of the time, Quite Often should be chosen. If you do a behaviour sometimes, you may want to chose On Occasion. Very rarely means that you rarely perform the actions that are described. Never means that you do not do the action that is described. Thank you very much for your participation.

How often do you...?	Very Often	Quite Often	On Occasion	Very Rarely	Never
1. Try to pass another car that is signaling a left turn	5	4	3	2	1
2. Select the wrong turn lane when approaching an intersection	5	4	3	2	1
3. Fail to 'Stop' or 'Yield' at a sign, almost hitting a car that has the right of way	5	4	3	2	1
4. Misread signs and miss your exit	5	4	3	2	1
5. Fail to notice pedestrians crossing when turning onto a side street	5	4	3	2	1
6. Drive very close to a car in front of you as a signal that they should go faster or get out of the way	5	4	3	2	1
7. Forgot where you parked your car in the parking lot	5	4	3	2	1
8. When preparing to turn from a side road onto a main road, you pay too much attention to the traffic on the main road so that you nearly hit the car in front of you	5	4	3	2	1
9. When you back up, you hit something that you did not observe before but was there	5	4	3	2	1
10. Pass through an intersection even though you know that the traffic light has turned yellow and may go red	5	4	3	2	1
11. When making a turn, you almost hit a cyclist or pedestrian who has come up on your right side	5	4	3	2	1
12. Ignore speed limits late at night or very early in the morning	5	4	3	2	1
13. Forget that your lights are on high beam until another driver flashes his headlights at you	5	4	3	2	1
14. Fail to check your rear-view mirror before pulling out and changing lanes	5	4	3	2	1
15. Have a strong dislike of a particular type of driver, and indicate your dislike by any means you can	5	4	3	2	1
16. Become impatient with a slow driver in the left lane and pass on the right	5	4	3	2	1
17. Underestimate the speed of an oncoming vehicle when passing	5	4	3	2	1
18. Switch on one thing, for example, the headlights, when you meant to switch on something else, for example, the windshield wipers	5	4	3	2	1

Appendix G

How often do you...?	Very Often	Quite Often	On Occasion	Very Rarely	Never
19. Brake too quickly on a slippery road, or turn your steering wheel in the wrong direction while skidding	5	4	3	2	1
20. You intend to drive to destination A, but you 'wake up' to find yourself on the road to destination B, perhaps because B is your more usual destination	5	4	3	2	1
21. Drive even though you realize that your blood alcohol may be over the legal limit	5	4	3	2	1
22. Get involved in spontaneous, or spur-of-the-moment, races with other drivers	5	4	3	2	1
23. Realize that you cannot clearly remember the road you were just driving on	5	4	3	2	1
24. You get angry at the behaviour of another driver and you chase that driver so that you can give him/her a piece of your mind	5	4	3	2	1

Appendix H

Cognitive Ergonomics Research Laboratory

Post-Drive Simulator Sickness Questionnaire

Instructions: The purpose of this questionnaire is to determine whether you experienced any illness while interacting with the driving simulator.

For each question, circle the number (1-10) that corresponds with the answer you wish to select.

1. To what extent did you experience nausea while driving the simulator?

1	2	3	4	5	6	7	8	9	10
None				Moderate					Severe

Comments:_____

_____

_____

_____

2. To what extent did you experience motion sickness while driving the simulator?

1	2	3	4	5	6	7	8	9	10
None				Moderate					Severe

Comments:_____

_____

_____

_____

3. To what extent did you experience disorientation while driving the simulator?

1	2	3	4	5	6	7	8	9	10
None				Moderate					Severe

Comments:_____

_____

_____

_____

4. To what extent did you experience any headaches while driving the simulator?

1	2	3	4	5	6	7	8	9	10
None				Moderate					Severe

Comments:_____

_____

_____

_____

5. To what extent did you experience eyestrain while driving the simulator?

1	2	3	4	5	6	7	8	9	10
None				Moderate					Severe

Comments:_____

_____

_____

_____

6. Were there any other physical symptoms you experienced while driving?

☐ Yes ☐ No

If yes, please describe:_____

_____

_____

_____

7. Were there particular points in the driving simulation when you felt more or less ill?

☐ Yes ☐ No

If yes, please describe:_____

_____

_____

_____

Thank you for filling out this questionnaire!

Appendix I

Media Questionnaire

Part 1

Prior to your participation in today's study, have you played any video games in the past 24 hours? If yes, specify which video games:	____Yes ____No
Have you been regularly playing video games on a **Game Console** (for example, XBOX 360, PlayStation 3, Wii, etc.) in the past **6 months?**	____Yes ____No
Have you been regularly playing video games on a **personal computer (PC)** in the past **6 months?**	____Yes ____No
If you have not been regularly playing video games on a **PC** or **Game Console** in the past 6 months, have you ever played video games before on a regular basis?	____Yes ____No
How many hours do you approximately spend playing **PC** or **Game Console** video games each week? (Please do not include time spent playing social media or cellular games.) ____ >1 hour ____ 2-4 hours ____5-7 hours ____ 8-10 hours ____ 10+ hours	
How skilled would you rate yourself at playing **PC** or **Game Console** video games? ____very good ____moderately good ____not very skilled ____not skilled at all	
Please list other platforms you play video games on other than PC or Game Consoles (for instance, social media games on Facebook or video games on your mobile phone).	
Do you consider yourself a "Gamer"?	____Yes ____No
Are you currently diagnosed with ADD/ADHD?	____Yes ____No
Have you ever felt like you have an addition to video games?	____Yes ____No

Video Gamer Specific

At what age did you start playing video games? _____	
Have you played any driving simulation video games?	____Yes ____No
Have you played any racing (vehicle) video games?	____Yes ____No

Appendix I

Please indicate the gaming consoles you have been regularly using in the last 6 months.

____ PlayStation 3 ____ PlayStation 2 ____ PlayStation ____ PC Gaming ____ Nintendo Wii	____ Nintendo GameCube ____ Xbox 360 S ____ Xbox 360 ____ Xbox	Other (specify):_____ Other (specify):_____ Other (specify):_____

Please list any **racing** or **driving** video games you have played in the past 6 months.

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

Please list the video games you have played the most in the past 6 months.

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

Please list your Top 6 video game genre/categories, that you enjoy playing.

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

Genres of video games		
• Action •Adventure •Arcade •City-building games •Economic simulation •Educational •Fighting •First-person shooter •Flight •God games	•Massive multiplayer online games •Maze •Military •Music •Pinball •Puzzle •Racing •Real-time strategy/ tactical and turn-based	•Role-playing •Simulators •Space •Sports •Stealth •Strategy puzzle games •Strategy war games •Survival horror •Vehicular combat

Part 2 – To be completed after the media condition

Have you ever seen the movie you watched today before?	___Yes ____No ___N/A
Have you ever played the video game you were played today before?	___Yes ____No ___N/A

On a scale of 1-7 please indicate how frustrating you found the media condition you just completed (with 1 indicating no frustration at all and 7 indicating extremely frustrated).

1 2 3 4 5 6 7

Part 3 – To be completed after the driving portion of the experimental session.

On a scale of 1-7 how **realistic** did you find driving the University of Calgary Driving Simulator to be (with 1 indicating not realistic at all and 7 indicating very realistic)?

1 2 3 4 5 6 7

On a scale of 0-7 how **seriously** did you take the driving component of today's session (with 1 indicating not serious at all and 7 indicating very seriously)?

1 2 3 4 5 6 7

On a scale of 1-7 how **similarly** did you drive the University of Calgary Driving Simulator to how you would drive your own vehicle (with 1 indicating not similar at all and 7 indicating very similarly)?

1 2 3 4 5 6 7

Do you think the media you were exposed to before the driving session influenced how **seriously** you treated the driving simulator?	____Yes ____No
Do you think the media you were exposed to before the driving session **helped** you to develop any skills that improved your driving in the driving simulator?	____Yes ____No
Do you think your **previous** video game experience helped you develop skills that improved your driving performance in the driving simulator?	____Yes ____No ____N/A
Did you partake in any deviant behaviour in the driving simulator such as speeding, traffic violations or unsafe driving behaviour?	____Yes ____No

If you answered "Yes" to the previous question, please explain what you did and your reasons for your driving behaviour. Would you perform this behaviour in your own vehicle?

Appendix I

In the simulated driving scenarios you were exposed to a number of potential driving hazards. Please answer the following questions regarding these driving events.

Pedestrian incursion event.

Were you able to anticipate this event?	
What actions did you take in response to the pedestrian?	
Did you attempt to hit the pedestrian?	
Did you want to hit the pedestrian, but refrained?	
Were the actions you took in the driving simulator similar to how you would react in your own vehicle?	

Late yellow light event.

What actions did you take in response to the traffic lights turning yellow?	
Did you attempt to stop or did you speed up?	
Were the actions you took in the driving simulator similar to how you would react in your own vehicle?	

Left turn across oncoming traffic.

How did you evaluate whether it was safe to make a left turn in the driving simulator?	
Do you recall making any unsafe left turns?	
Did you race or speed to make a left turn crossing oncoming traffic? Did you want to, but refrained?	
Were the actions you took in the driving simulator similar to how you would react in your own vehicle?	

Vehicle pull-out event.

Were you able to anticipate this event?	
What actions did you take in response to the pull-out vehicle?	
Did you attempt to collide with the pull-out vehicle? Did you want to, but refrained?	
Were the actions you took in the driving simulator similar to how you would react in your own vehicle?	

Appendix I

Appendix J

Debrief

Thank you very much for your participation. Your assistance has helped us.

The purpose of this research is to determine how media such as video games might affect driving performance and behaviour. Over the course of the experimental session, you were exposed to a variety of road types, driving conditions, and hazards. We were interested in finding out how media, specifically video games as well as video game experience affects driving performance.

Movies and television shows that show inappropriate or dissenting behaviour have been blamed for leading to the aggressive or inappropriate behaviour of some viewers. Now video games are facing the same criticism. Researchers investigating the effects of violent, first person shooter games on aggression-related cognitions have shown some positive correlations and suggest that playing violent shooting games may contribute to the likelihood of someone actually participating in a violent event. However, these activities or events are relatively exceptional. But what about more common, day-to-day activities like driving? How do video games and more specifically car racing games affect driving behaviour?

Racing and virtual driving games represent a popular genre of video games on the market. Many of these games promote and reward deviant driving behaviour that is risky, harmful and aggressive. For example, some racing or virtual driving games have promoted anti-social driving behavior including illegal driving, from speeding and aggressive driving to running from the police, street racing, and even stealing cars. However, do these games actually lead people to drive more aggressively and thus more dangerously? This is an important question because aggressive driving (e.g., speeding, following too close, and weaving in and out of traffic) has been shown to increase crash risk. Despite the popularity of racing games and the increasing number of drivers on the road, few studies have actually attempted to tackle this question.

During the experimental session, specific information was collected by the simulator such as speed, lane position, and reaction time to specific events. The data gathered from this experiment will be used to understand the affects of media on driving performance and behavior in response to driving events, and video game experience.

You are welcome to contact us for results or any other information you want regarding this study. Do you have any further questions about the study? Is there anything that you did not understand about the study or the research?

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