CJLT RCAT
Canadian Journal of Learning and Technology
La Revue canadienne de l'apprentissage et de la technologie

Volume 41(2) Spring/Printemps 2015

Does Simulator Sickness Impair Learning Decision Making While Driving a Police Vehicle?

Le mal du simulateur: un frein à l'apprentissage de la prise de décision en conduite d'un véhicule de police?

Eve Paquette, *École nationale de police du Québec*
Danielle-Claude Bélanger, *École nationale de police du Québec*

Abstract

The use of driving simulators is an innovation for police training in Quebec. There are some issues related to their impact on training objectives. This article presents the results of a study involving 71 police cadets who participated in six training sessions with a driving simulator. The training sessions were designed for developing the decision-making skills in regard to emergency driving and pursuit. The nature and consequences of the discomfort experienced by the participants is described. The results highlight the importance of the initial training session. Issues related to providing trainees with adequate support are discussed.

Résumé

Le simulateur de conduite est un outil pédagogique novateur pour la formation policière au Québec. Il comporte des enjeux à l'égard de l'atteinte des objectifs pédagogiques visés. L'article présente les résultats d'une recherche menée auprès de 71 aspirants policiers ayant participé à une formation de six séances au simulateur de conduite visant le développement des compétences en matière de prise de décision en conduite d'urgence et en poursuite. Les résultats dressent un portrait des malaises ressentis par les participants et de leurs impacts. Les résultats montrent également l'importance de la première séance. La discussion s'attarde aux enjeux liés à l'accompagnement des apprenants.

Introduction

Although the integration of simulators into police training in Quebec is an innovation offering many advantages, it also raises questions regarding the fulfilment of training objectives. The driving simulator provides an opportunity for cadets to drive a police vehicle in an environment where their safety and that of the population is not put at risk. This educational tool is also used to develop scenarios involving real-time decision-making. Thus, the cadets can immediately see the impact of their decisions. Several studies have reported the occurrence of symptoms or discomfort in individuals exploring virtual reality environments (Bergeron, Paquette, & Thiffault, 2001; Howarth & Finch, 1999; Lawson, Sides, & Hickinbotham, 2002; McCauley, 1984; Regan, 1997; Trick & Caird, 2011). More specifically, users of driving simulators may develop some physiological reactions known as 'simulator sickness'. These reactions may be serious enough to interfere with training activities (Kolasinski, 1995; Mollenhauer, 2004). In light of this, this article will: 1) establish the prevalence of simulator sickness for the cadets who participated to the study; 2) characterize the adaptation of trainees to the driving simulator training program; 3) shed light on the impact of this condition on training activities intended to develop decision making during emergency driving and pursuits.

This study confirms the interest of integrating virtual reality technologies into police training, with the caveats that special attention must be paid to the initial training session and that trainees, most of whom adapt well, receive adequate support. It is also true that concern for trainees must be paralleled by preparation of instructors. Our conclusions indicate some way of ensuring this.

Literature Review

Simulator Sickness

Some individuals who drive in a virtual reality environment experience malaises that resemble motion sickness. These symptoms may take the form of nausea, dizziness, visual disturbances, headaches, heat flashes, or excessive perspiration (Mullen, Weaver, Riendeau, Morrison, & Bédard, 2010). Several terms are used for this condition: cybersickness (McCauley & Sharkey, 1992), simulator sickness (Havron & Butler, 1957; Kolasinski, 1995), and simulator adaptation syndrome (SAS) (Kennedy & Fowlkes, 1992; Mollenhauer, 2004).

The symptoms experienced while in a virtual environments have several, complex causes and can present in many forms (Kennedy & Fowlkes, 1992). While symptoms can appear while driving a simulator, studies reported that observers can feel those even if they are not the ones driving (Kolasinski, 1996; Lin, Abi-Rached, & Lahav, 2004). This implies that merely observing a simulator exercise (for example, a scenario involving the participation of a co-pilot), may compromise the ability of trainees subject to simulator sickness to perform the exercise themselves.

Causes of Simulator Sickness

Several causes have been advanced for simulator sickness. The most common explanation draws on cue conflict theory (Reason & Brand, 1975). This explanation posits that the symptoms of simulator sickness result from discrepancies between visual cues and cues from the vestibular system (in the inner ear), responsible for motion perception and vertical body orientation (LaViola Jr., 2000). Thus, the symptoms observed are thought to be reactions to ongoing discrepancies between the body's immobile state and visual cues indicating vehicular acceleration or deceleration.

Postural instability has also been advanced as a cause of simulator sickness (Riccio & Stoffregen, 1991). Individuals reporting discomfort while in a virtual realities have exhibited postural instability (Stoffregen, Hettinger, Haas, Roe, & Smart, 2000), and the reported symptoms are thought to result from a failure to develop effective equilibrium-maintenance strategies (Duh, Parker, & Furness, 2004). Because posture is a function of activity, situations (real or virtual) which inhibit postural control result in discomfort (LaViola Jr., 2000), with symptom intensity determined by the duration and intensity of the postural instability. For example, a body subjected to wave movement will adapt to this environment given sufficient time, but once back must relearn equilibrium-maintenance strategies, both for standing still and moving.

Prevalence of Simulator Sickness

Between 5% and 10% of simulator users experience no malaise the first time they use the simulator, and between 5% and 30% of users experience malaise so strong that they must terminate the simulation (Lawson et al., 2002; Mullen et al., 2010; Stanney, Hale, Nahmens, & Kennedy, 2003; Stanney & Salvendy, 1998; Straus, 2005). The vast majority of users thus experience some symptoms, of variable intensity, during their initial simulator session (Lawson et al., 2002; Stanney et al., 2003; Stanney & Salvendy, 1998).

Adaptation to Virtual Reality

Most symptoms of simulator sickness disappear after one or two hours after the simulation session (Johnson, 2005). Nevertheless, some users of simulators have reported simulator-related symptoms up to 24 hours following their simulator session (LaViola Jr., 2000; Stanney et al., 2003; Stoner, Fisher, & Mollenhauer, 2011). This may be an issue if students begin their training day with a simulator session and have symptoms during the day.

The reported prevalence of simulator sickness varies greatly from one study to another, and reflects differences in socio-demographic characteristics (e.g. age), the type of virtual reality and the physical reliability of the equipment (e.g. fixed-base or dynamic), the reliability of the equipment, the type of tasks performed (e.g. driving in a straight line, turning), and the measurement protocol for simulator sickness (e.g. instruments, time at which measurements were taken) (Kennedy & Fowlkes, 1992; McCauley, 1984).

In most individuals experiencing simulator sickness, symptoms increase over the course of a single session but decrease from one session to another (Domeyer, Cassavaugh, & Backs, 2013; Howarth & Hodder, 2008; Kennedy, Stanney, & Dunlap, 2000; Park et al., 2008; Stanney et al., 2003). Although the majority of trainees adapt to driving simulators, it appears that approximately 3% of the population is incapable of adapting to virtual environments (Howarth & Hodder, 2008).

Impact of Simulator Sickness on Performance

Individuals experiencing discomfort in virtual environments have been reported to exhibit decreased performance (Mullen et al., 2010; Stoner et al., 2011), and modify their behaviour and even adopt inappropriate behaviours to reduce their discomfort (Reed Jones, 2011; Silverman & Slaughter, 1995). For example, drivers may avoid looking at the screen, which alters their visual scanning, an essential component of safe driving. Symptoms may also decrease motivation and concentration (Kennedy et al., 1987). Moreover, intense symptoms may lead individuals to terminate their training session (Edwards, Creaser, Caird, Lamsdale, & Chisholm, 2003; Harm, 2002). Consequently, simulator sickness may hinder learning, prevent trainees from benefiting from training activities, and, ultimately, limit the evaluation of driving competencies through the use of simulated driving (Edwards et al., 2003).

Objectives

The statistical portrait of simulator sickness reported in the literature varies according to several factors related to sampling, exposure to the virtual environment and the equipment used. However, the majority of virtual environment users feel discomfort. Some users feel such strong discomfort they must stop their immersion. Discomfort will decrease over repeated exposures for the majority of users, but some users would never be able to adapt. Discomfort also seems to have an impact on the learner's learning and behaviour. Thereby, there is insufficient knowledge for the estimation of the extent of the symptoms experienced by trainees undergoing driving simulations and the impact of these symptoms on learning. In the context of the integration of the driving simulator in a training program, the potential impact of simulator sickness on learning renders research particularly relevant. Accordingly, the three objectives of this study were to:

1. Determine the prevalence and incidence of simulator sickness in police cadets during, immediately after, and between simulator sessions.
2. Evaluate the adaptation of police cadets to the driving simulator training program, in terms of the intensity of symptoms, the variation in symptoms throughout simulator sessions, and the persistence of symptoms.
3. Evaluate the perceptions of police cadets on the impact of their symptoms on their performance, and determine the number of dropouts due to these symptoms.

Method

Participants

The study participants were the members of the first cohort of police cadets at the École nationale de police du Québec (ENPQ) to have received simulator-based driving training. Measurements were taken during the cadets' regular training. This cohort comprised 71 cadets—46 men (65%) and 25 women (35%)— whose age varied from 20 to 36 years (*M* = 22.6 years).

Procedure and Equipment

The simulator sessions are part of a training program that also includes theoretical learning and other practical activities such as driving on a closed-road circuit. Data was collected over six periods from December 2012 to January 2013: four training sessions in emergency driving, and two training sessions in pursuit and interception. The objective of the first session was to become familiar with the parameters of the simulator and to develop observation skills. The second session was about adapting one's driving to the situation during an emergency call. The cadets had to be aware of the environment (i.e. weather conditions, traffic configuration, context of the call) in which they operate and adapt their driving accordingly. The third session offered to cadets a simple intersection clearing scenario, either through a red light or a stop sign, during an emergency call. The fourth session dealt with multiple intersections clearing scenario, either through a red light or a stop sign at double-lane intersections. In each of the four sessions, one or two scenarios were performed and the student was spending a maximum of 10 minutes at the simulator, including instructions and feedback from the instructor. The fifth and the sixth sessions proposed scenarios during which the cadets had to apply the knowledge about the deciding factors to initiate, maintain or stop a pursuit. Cadets performed a scenario as a driver and a scenario as a co-pilot for both sessions. All six training sessions were designed to help developing decision-making skills.

All the cadets have agreed to sign an ethical consent form in the first session and they completed a questionnaire at the end of each session. It should be noted that the results of the sixth session are based on only 65 cadets, as six cadets were unable to participate due to a technical problem.

Cadets received driving training in two fixed-base driving simulators that reproduced the interior of a patrol car, including a dashboard and switches to activate sirens and revolving lights. Three screens provide a 180° field of vision, which favours immersion of the driver in a virtual reality environment (Figure 1).

Figure 1. A driving-simulation session.

Measurements

Individual simulator training self-report. After each of the six simulator sessions, the cadets completed an individual training report which collected the following information:

1. Socio-demographic information (gender, age).
2. Cadets' perceptions of the impact of their symptoms on their performance. Cadets were asked to respond to the statement "I believe that the symptoms associated with use of the simulator affected my performance". Four responses were available: none (0); slightly (1); moderately (2); strongly (3).
3. Dropouts, measured through the following question: "Did you complete all the pre-determined scenarios? Yes/No".

Simulator Sickness Questionnaire (SSQ). The French version of the Simulator Sickness Questionnaire (SSQ; Kennedy, Lane, Berbaum, & Lilienthal, 1993) was used to collect information on the symptoms associated with the use of a driving simulator. This instrument evaluates post-simulation symptoms, and collects information on the intensity (0 = none; 1 = slight; 2 = moderate; 3 = severe) of 16 symptoms of simulator sickness related to nausea (e.g.

increased salivation), oculomotor disturbances (e.g. eye fatigue, blurred vision), and disorientation (e.g. dizziness, vertigo). At the end of every session, cadets reported any symptoms they experienced between the previous session and the current one, during the current session, and immediately after the current session. The SSQ allows calculation of a total intensity score for reported symptoms.

Data Analysis Strategy

To achieve the objective of this research, which is to draw up a portrait of simulator sickness among cadets who participated in the training, descriptive and non-parametric analyses were conducted. Other univariate or multivariate analyses would have required the withdrawal of participants or the modification of distributions, which would have allowed the achievement of other objectives.

Results

Prevalence and Incidence of Simulator Sickness

Symptoms experienced during the sessions. In this study, 'prevalence' refers to the total number of cadets who experienced at least one symptom, and 'incidence' refers to the number of cadets who experienced at least one symptom for the first time. During the first simulator session (acclimatization session), the prevalence of symptoms was 76.1% (see Figure 2). In general, the symptom prevalence decreased as the training progressed. By the sixth session, almost 17% of cadets still reported at least one symptom. Over the course of the six simulator sessions, 18.3% (n = 13) of the cadets reported no symptoms. With regard to incidence, 5.6% (n = 4) of the cadets reported no symptoms during the first session, but at least one symptom in any other sessions. More specifically, 1.4% (n = 1) of the cadets reported experiencing at least one symptom for the first time during the second session, 4% (n = 1) during the third session, and 2.8% (n = 2) reported experiencing at least one symptom for the first time during the fifth session.

In all six sessions, general discomfort was the most frequently reported symptom (M = 15.0 cadets per session). In addition, fullness of head (M = 9.0 cadets per session) and dizziness with eyes open (M = 7.5 cadets per session), headache (M = 7.0 cadets per session) and nausea (M = 5.5 cadets per session) were also frequently reported.

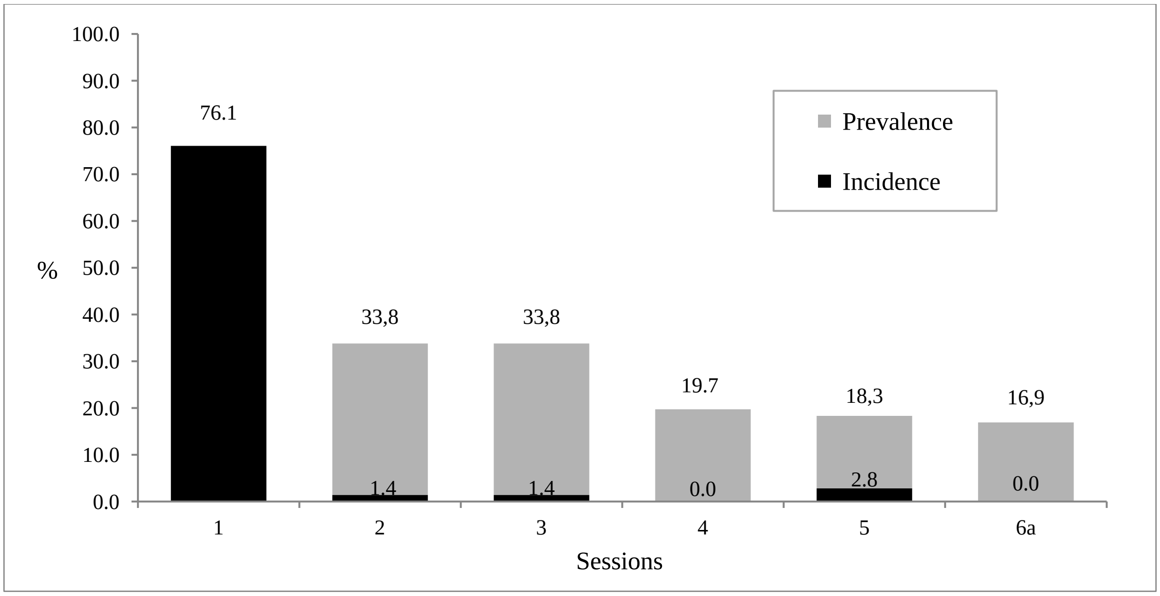

Figure 2. Prevalence and incidence of cadets (*N* = 71) reporting at least one SSQ symptom, for each simulator session. Prevalence = total number of cases of at least one symptom; incidence = number of new cases of at least one symptom. [a] *n* = 65 for the sixth session.

Symptoms experienced immediately after the sessions. Almost one third (32%, *n* = 23) of the cadets reported experiencing at least one symptom immediately after their first simulator session (see Table 1). The percentage of cadets who reported at least one symptom varied from session to session, but a decreasing trend is observed. However, this trend is not perfectly linear: no cadets reported experiencing simulator sickness symptoms immediately after the third session but the number increases at 20% (*n* = 14) for immediately after the fourth session. It decreases at 11% in the fifth session and was at 14% (*n* = 9) in the sixth session.

Table 1
Number of police cadets (N = 71) reporting at least one symptom immediately after the sessions

Sessions	n	%
1	23	32
2	14	20
3	0	0
4	14	20
5	8	11
6[a]	9	14

Note. [a] *n* = 65 for the sixth session.

Between sessions symptoms. Almost 20% of the cadets (*n* = 14) reported experiencing symptoms between the first and the second sessions (see Table 2). From the second to the fifth sessions, few cadets (4.2% to 7%) reported experiencing symptoms between sessions. The most common symptoms were slight headaches, nausea, and dizziness. No cadet reported experiencing symptoms between the fifth and the sixth sessions.

Table 2
Number of cadets (N = 71) having experienced at least one symptom between sessions

Sessions	n	%
1 - 2	14	19.7
2 - 3	4	5.6
3 - 4	5	7.0
4 - 5	3	4.2
5 - 6[a]	0	0

Note. [a] *n* = 65 for the sixth session.

Adaptation to Virtual Reality

Symptom intensity and fluctuation over time. The number of cadets experiencing symptoms gradually decreased as the training progressed. However, the mere occurrence of symptoms is an insufficient measure of the scope of cadets' discomfort; the intensity and fluctuation of symptoms over time must also be taken into consideration. Figure 3 presents the mean SSQ score for the cadets who participated in all six simulator sessions (*n* = 65).

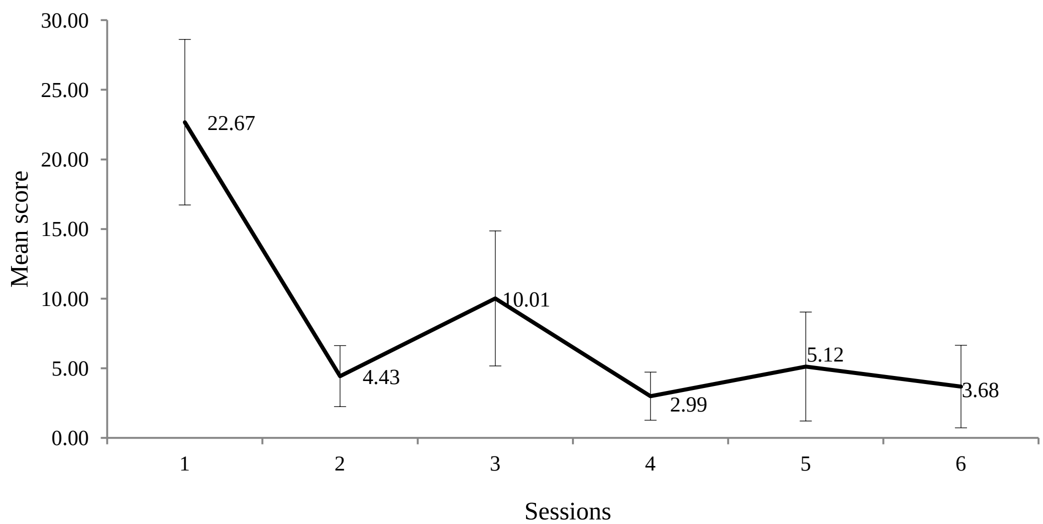

Figure 3. Mean SSQ scores for each simulator session (*n* = 65). The vertical bars represent the 95% confidence intervals.

The mean score decreased from 22.67 (95 % CI [16.73, 28.62]) for the first session to 3.68 (95 % CI [0.72, 6.65]) for the sixth session. A non-parametric Friedman test showed a statistically significant reduction of symptoms over time on the total score of the SSQ with a Chi-square value of 116.50 ($p < .001$). There was thus a tendency for mean SSQ scores to gradually decrease, although the third session mean score ($M = 10.01$, 95 % CI [5.16, 14.86]) was slightly but significantly (Chi-square value of 5.45 $p = .020$) higher than the second session mean score ($M = 4.43$, 95 % CI [2.24, 6.62]).

Symptoms persistence. Although there was a general tendency for symptoms to decrease in intensity over the six sessions, did some cadets have difficulty adapting to the driver simulator? One way of answering this question is to determine the number of cadets experiencing persistent symptoms. There were two sub-groups of cadets with persistent symptoms. First, 7% ($n = 5$) of the cadets reported experiencing at least one symptom in every session. Second, 16.9% ($n = 11$) of the cadets reported experiencing at least one symptom in the sixth session. It is to be noted that students who chose not to drive for at least one session are not included in the group of cadets who experienced at least one symptom in every session ($n = 5$). In addition, students from the subgroup of cadets who experienced at least one symptom in every session ($n = 5$) are part of the same cadet group having experienced one symptom in the sixth session ($n = 11$). This is why the group of 11 cadets was kept to identify the students who persistently experienced the symptoms.

As presented in Figure 4, the mean SSQ scores (i.e. the intensity of symptoms) of this cadet sub-group experiencing persistent symptoms were higher than the mean SSQ scores of the rest of the sample. The SSQ mean score is relatively high in the first session for both groups ($M = 50.66$ CI [27.62, 73.70] and $M = 16.97$ CI [12.42, 21.52]). While the means scores of the rest of the cohort decrease substantially with the sessions, those of the sub-group remain relatively high. The cadets in this sub-group appear to potentially have difficulty adapting to simulated driving.

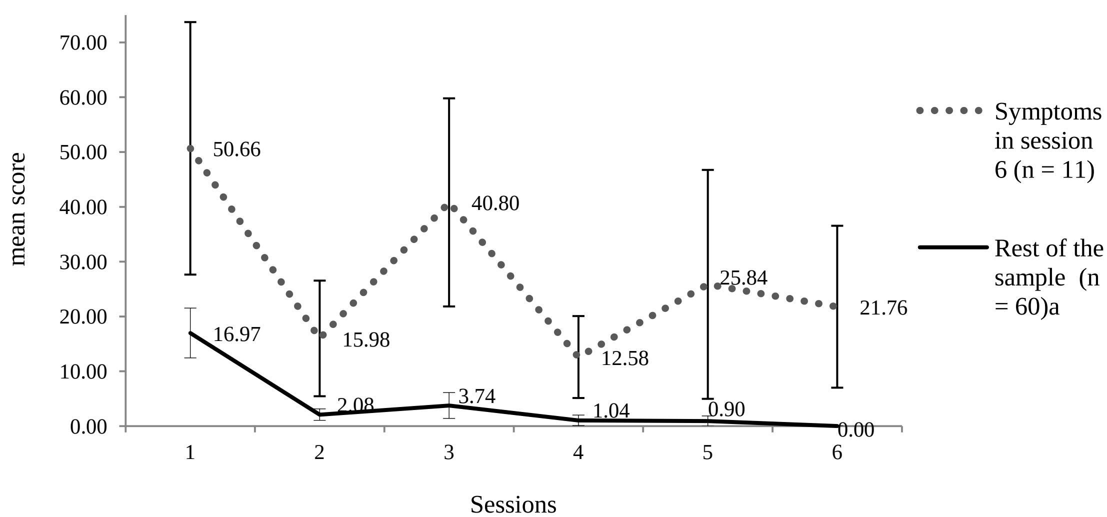

Figure 4. Mean SSQ scores for each session, for cadets experiencing symptoms in the sixth session ($n = 11$), and the rest of the sample ($n = 60$). [a] $n = 54$ for the sixth session. The vertical bars represent the 95% confidence intervals.

Impacts of Simulator Sickness on Performance

Perceived impacts of symptoms on performance. Of the 54 police cadets who reported experiencing symptoms in the first session, slightly more than 66% stated that their symptoms had affected their performance; the impact on performance ranged from slight (42.6%) to strong (5.6%) (Figure 5). The number of cadets experiencing symptoms that affected performance decreased as training progressed. However, this decrease was not linear, as 65% of cadets reported performance-affecting symptoms in the third session (slight: 56%, strong: 4.3%). A moderate or strong impact on performance was reported by 4.2% of cadets having experienced symptoms in the second session, by 7.6% in the third session, and by 15.4% in the fifth session. In the sixth session, slightly more than 27% of cadets having experienced symptoms reported a slight impact in perfomance.

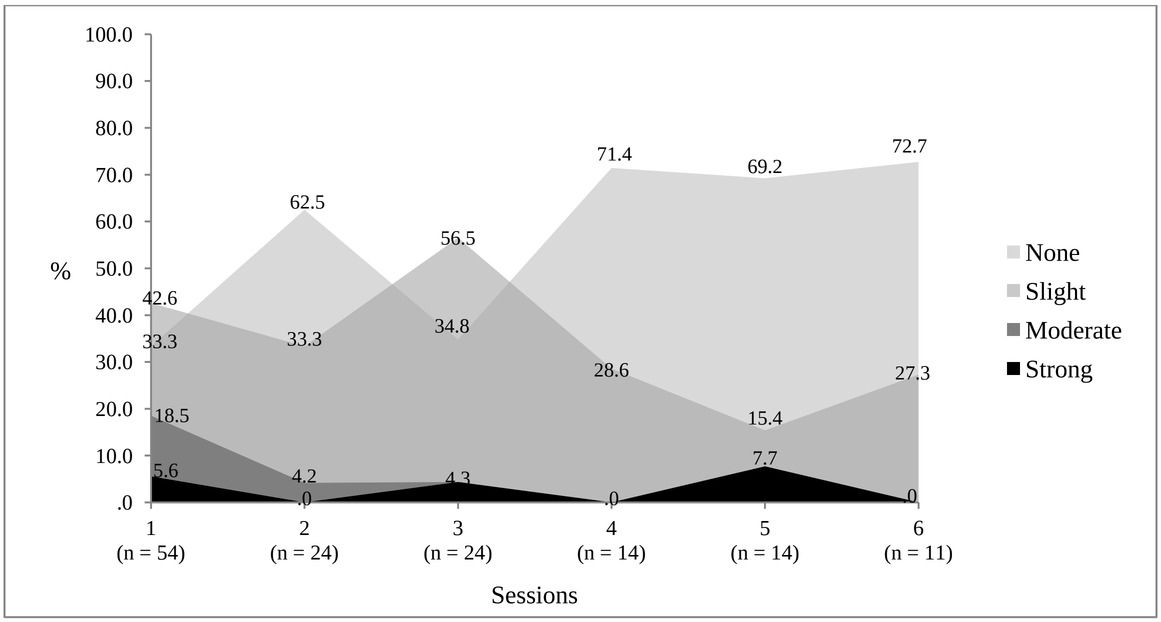

Figure 5. Perceived impact of symptoms on performance among cadets having experienced symptoms.

Dropout

Two types of dropout were observed during: premature termination of a training activity and failure to participate in a training activity. Of the 71 cadets, two dropped out. One cadet prematurely terminated four simulator sessions (sessions 1, 2, 3, 5) and chose to not participate in the driving portion of the sixth session. Although he did not participate in the simulated driving portion of the sixth session, this cadet nevertheless experienced symptoms while watching the screens during the activity carried out by other cadets. The second cadet prematurely terminated simulator during the first and the third sessions, and chose to not participate in the simulated portion of the fourth session; he reported no symptoms while watching the screens of other cadets in this session. Both cadets who dropped out were part of the sub-group of 11 cadets who may have difficulty adapting to simulated driving.

Discussion

The objective of this study was to determine the prevalence of simulator sickness among police cadets, describe cadets' adaptation to simulated driving, and shed light on the impact of simulator-related discomfort on training activities. The results obtained have implications on various aspects of training.

Occurrence of Simulator Sickness and Scope of the First Session

The results indicate that simulator sickness is particularly common at the beginning of training. Thus, three quarters (76%) of cadets experienced at least one symptom during the initial simulator session (acclimatization session), almost one third (32%) experienced at least one symptom immediately after the initial session, and almost 20% experienced symptoms between the first and the second sessions. In light of these results, trainers should pay particular attention to the initial session and plan activities that favour adaptation to virtual environments (LaViola Jr., 2000; Stanney, Kennedy, & Kingdon, 2002). For example, a session with short scenarios that require simple driving maneuvers is preferable. During each of the six sessions, at least 15% of the cadets experienced at least one symptom. On the other hand, 18% of the cadets (n = 13) didn't feel any symptoms during the six sessions.

Adaptation to Driving Simulator

The number of cadets who experienced symptoms, as well as the intensity of the symptoms, gradually decreased as training progressed, indicating an adaptation. This finding is consistent with that of other studies (Domeyer et al., 2013; Howarth & Hodder, 2008; Kennedy et al., 2000; Park et al., 2008; Stanney et al., 2003). However, symptom intensity in the third session was significantly higher than that in the second session. The third session may have been more stressful than the others, as it required cadets to go through an intersection in which they did not have priority (stop sign, red traffic light), using a predetermined protocol. These results highlight the necessity of planning for cadets' gradual adaptation to driving simulator, exercises whose difficulty is progressive, and introducing more complex tasks later in the training program, once the students have had the opportunity to adapt. Research in this area has focused on the judicious selection of manoeuvres and the impact of symptoms reduction between sessions (Domeyer et al., 2013; Kennedy et al., 2000).

Persistence of Symptoms in a Sub-group of Cadets

Some cadets exhibited persistent symptoms. Although most cadets adapted to simulated driving, the literature reports that between 3% and 5% of the population is unable to adapt to virtual environments (Howarth & Hodder, 2008; Johnson, 2005). In the present study, 16.9% of cadets (n = 11) experienced symptoms that persisted from one session to another and were more intense than those reported by other cadets. These cadets might potentially be the ones who present adaptation issues to the driving simulator. These results underscore the importance of identifying strategies that help reduce symptom occurrence (Reed Jones, 2011; Stoner et al., 2011).

The Impact of Symptoms on Performance and Dropout

Cadets who experienced symptoms were not necessarily disturbed or incapacitated by them. Analysis of the perceived impact of discomfort on performance revealed that the occurrence of discomfort is not invariably associated with a perceived performance deficit. In fact, 75.9% of cadets who experienced symptoms in the first session stated that their symptoms had affected their performance slightly or not at all, and the majority of cadets who experienced symptoms in sessions 2, 4, 5, 6 stated that their symptoms had not affected their performance at all. All cadets who reported that their symptoms had moderately or strongly affected their performance during these sessions were part of the sub-group of cadets who may have difficulty adapting to the driving simulator.

The dropout rate in this sample was lower than the 5-30% reported in the literature (Lawson et al., 2002; Mullen et al., 2010; Stanney et al., 2003; Stanney & Salvendy, 1998; Straus, 2005). Two cadets (2.8%) were unable to complete at least two sessions: either they prematurely terminated their simulator session or they chose to not drive.

Studies of driving simulators usually exclude participants who drop out of a session because of discomfort. But in a training context, the occurrence of incapacitating symptoms and of dropping out are not incidental events, as simulated driving is intended to equip students with specific competencies. The alternative to simulated driving is observation of other students, who do in fact drive. It is true that this strategy allows students to acquire the knowledge delivered by instructors. However, the ENPQ's simulator training targets decision making, and mere observation does not allow cadets to exercise their judgement in real time and receive pertinent personalized feedback.

Limitations

Two limitations must be borne in mind when interpreting the results presented here. First, the data collected was self-reported. Because successful completion of the training program is the only way to become a police officer, cadets may have fallen prey to the temptations of social desirability, and striven to make a good impression by hiding some of their symptoms. As self-report measures, direct observation and physiological measures also have limitations. On the one hand, our own observations reveal that it is difficult to detect students who experience symptoms by direct observation. A pilot study showed that the number of cadets who reported experiencing discomfort is significantly higher than what we could infer from verbal comments and responses during the experiment. On the other hand, physiological measurements are invasive and especially more expensive. Although the physical measurements of simulator sickness are a promising way (Min, Chung, Min, & Sakamoto, 2004), searches are few (Classen, Bewernitz, & Shechtman, 2011) and not all conclusive (Casali & Frank, 1988). Thus, our applied research approach serves a different purpose of experimental research. Second, the cadets in this study were the first to receive training of this sort. The implementation of a new training program may be responsible for increased stress in both students and instructors, and may thus influence the profile of simulator sickness reported here.

Conclusion

Simulator Sickness: An Obstacle to Learning?

Although it is not an obstacle to learning, the introduction of driving simulators into a training program requires special planning, in terms of both preparation of training personnel and students, and of training schedule. The results of this study indicate that the initial simulator session exerts a critical influence, as a large majority of cadets experienced discomfort during it. Nevertheless, the results also indicate that a large majority of cadets adapt to the driving simulator. However, a small number of cadets did not adapt within the study period and some cadets reported that their discomfort had affected their performance.

These results do not call into question the use of driving simulators in ENPQ training programs. Simulators are training tools which allow cadets to exercise their judgement and experience pursuit and emergency driving situations in total safety. The integration of driving simulators into police training is thus largely justified by the reduction of risk to the general public and the cadets themselves, and the integration of a wider variety of police activities into training programs.

Future Research

This research program and the results reported here suggest two avenues of future research. First, as most research on driving simulator training excludes students with significant adaptation difficulties, knowledge on this subject is limited. From a training perspective, further knowledge on the persistence of adaptational difficulties would be helpful. Similarly, the development, implementation and evaluation of protocols for the reduction of the symptoms of simulator sickness would render simulated-driving training more effective. Secondly, ENPQ research has generally indicated that individuals who experience simulator-induced symptoms cannot be identified on the basis of observation alone. In the pilot study for the study reported here, the number of cadets who reported experiencing simulator-related symptoms was much higher than that expected on the basis of the cadets' behaviours and statements during the simulator sessions. This finding was replicated in the study reported here. The development of an instrument capable of detecting students experiencing symptoms would allow trainers to provide more effective support.

References

Bergeron, J., Paquette, M., & Thiffault, P. (2001). *Évaluation sur simulateur de conduite de l'efficacité du présignalement d'arrêt pour les autobus scolaires* (RTQ-01-01). Retrieved from www.mtq.gouv.qc.ca/portal/page/portal/Librairie/Publications/fr/ministere/recherche/etudes/rtq01-01.pdf

Bouchard, S., Robillard, G., Renaud, P., & Bernier, F. (2011). Exploring new dimensions in the assessment of virtual reality induced side-effects. *Journal of Computer and Information Technology*, *1*(3), 20-32. Retrieved from http://www.academypublish.org/papers/pdf/546.pdf

Casali, J., & Frank, L. (1988). Manifestation of visual/vestibular disruption in simulators: severity and empirical measurement of symptomatology. *Proceedings of the AGARD conference, Motion cues in flight simulation and simulator induced sickness, Brussels, Belgium, 433*, 11.11-11.18.

Classen, S., Bewernitz, M., & Shechtman, G. (2011). Driving simulator sickness: An evidence-based review of the literature. *American Journal of Occupational Therapy, 65*(2), 179-188. http://dx.doi.org/10.5014/ajot.2011.000802

Domeyer, J. E., Cassavaugh, N. D., & Backs, R. W. (2013). The use of adaptation to reduce simulator sickness in driving assessment and research. *Accident, Analysis and Prevention, 53C*, 127-132. http://dx.doi.org/10.1016/j.aap.2012.12.039

Duh, H. B. L., Parker, D. E., & Furness, T. A. (2004). An independent visual background reduced simulator sickness in a driving simulator. *Presence-Teleoperators and Virtual Environments, 13*(5), 578-588. http://dx.doi.org/10.1162/1054746042545283

Edwards, C. J., Creaser, J. I., Caird, J. K., Lamsdale, A. M., & Chisholm, S. L. (2003). *Older and younger driver performance at complex intersections: Implications for using perception-response time and driving simulation*. Paper presented at the Second International Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design, Park City, UT. Retrieved from http://trid.trb. org/view/698784

Harm, D. L. (2002). Motion sickness neurophysiology, physiological correlates, and treatment. In K. M. Stanney (Ed.), *Handbook of virtual environments: Design, implementation, and applications* (pp. 637-662). Mahwah, NJ: Lawrence Erlbaum Associates.

Havron, M. D., & Butler, L. F. (1957). *Evaluation of training effectiveness of the 2FH2 helicopter flight trainer research tool* (Tech. Report NAVTRADEVCEN 1915-00-1). Port Washington, NY: Naval Training Device Center.

Howarth, P. A., & Finch, M. (1999). The nauseogenicity of two methods of navigating within a virtual environment. *Applied Ergonomics, 30*, 39-45. http://dx.doi.org/10.1016/S0003-6870(98)00041-6

Howarth, P. A., & Hodder, S. G. (2008). Characteristics of habituation to motion in a virtual environment. *Displays, 29*(2), 117-123. http://dx.doi.org/10.1016/j.displa.2007.09.009

Johnson, D. M. (2005). *Introduction to and Review of Simulator Sickness Research*. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences. Retrieved from http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA434495

Kennedy, R. S., Berbaum, K. S, Lilienthal, M. G, Dunlap, W. P, Mulligan, B. E, & Funaro, J. F. (1987). *Guidelines for alleviation of simulator sickness symptomatology* (NAVTRASYSCEN TR-87-007). Orlando, FL: Naval Training Systems Center. Retrieved from http://www.dtic.mil/docs/citations/ADA182554

Kennedy, R. S., & Fowlkes, J. E. (1992). Simulator sickness is polygenic and polysymptomatic: Implications for research. *The International Journal of Aviation Psychology, 2*(1), 23-38. http://dx.doi.org/10.1207/s15327108ijap0201_2

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator sickness questionnaire: an enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology, 3*(3), 203-220. http://dx.doi.org/10.1207/s15327108ijap0303_3

Kennedy, R. S., Stanney, K. M., & Dunlap, W. P. (2000). Duration and exposure to virtual environments: Sickness curves during and across sessions. *Presence-Teleoperators and Virtual Environments*, *9*(5), 463-472. http://dx.doi.org/10.1162/105474600566952

Kolasinski, E. M. (1996). Prediction of simulator sickness in a virtual environment. (Doctoral dissertation, University of Central Florida). Retrieved from www.hitl.washington.edu/scivw/kolasinski

Kolasinski, E. M. (1995). *Simulator sickness in virtual environments*. Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences. Retrieved from www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA 295861

LaViola Jr., J. J. (2000). A discussion of cybersickness in virtual environments. *ACM SIGCHI Bulletin, 32*(1), 47-56. Retrieved from http://dl.acm.org/citation.cfm?id=333344

Lawson, B. D., Sides, S. A., & Hickinbotham, K. A. (2002). User requirements for perceiving body acceleration. In K. M. Stanney (Ed.), *Handbook of virtual environments: Design, implementation, and applications* (pp. 135-161). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Lin, J. J. W., Abi-Rached, H., & Lahav, M. (2004). Virtual Guiding Avatar: An Effective Procedure to Reduce Simulator Sickness in Virtual Environments. *Proceedings of the Special Interest Group on Computer-Human Interaction (SIGCHI), Vienna, Austria,* 719-726. Retrieved from ftp://hitl.washington.edu/pub/publications/r-2005-2/r-2005-2.pdf

McCauley, M. E. (1984). *Research issues in simulator sickness: Proceedings of a workshop.* Washington, DC: National Academies Press. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a148543.pdf

McCauley, M. E., & Sharkey, T. J. (1992). Cybersickness: Perception of self-motion in virtual environments. *Presence, 1*(3), 311-318.

Min, B. C., Chung, S. C., Min, Y. K., & Sakamoto, K. (2004). Psychophysiological evaluation of simulator sickness evoked by a graphic simulator. *Applied Ergonomics*, *35*(6), 549-556. http://dx.doi.org/10.1016/j.apergo.2004.06.002

Mollenhauer, M. A. (2004). *Simulator adaptation syndrome literature review*. Royal Oak, MI: Realtime Technologies Inc. Retrieved from www.simcreator.com/documents/papers/simadaptsyndrome.pdf

Mullen, N. W., Weaver, B., Riendeau, J. A., Morrison, L. E., & Bédard, M. (2010). Driving performance and susceptibility to simulator sickness: Are they related? *American Journal of Occupational Therapy*, *64*(2), 288-295. http://dx.doi.org/10.5014/ajot.64.2.288

Park, J. R., Lim, D. W., Lee, S. Y., Lee, H. W., Choi, M. H., & Chung, S. C. (2008). Long-term study of simulator sickness: Differences in EEG response due to individual sensitivity. *International Journal of Neuroscience*, *118*(6), 857-865. http://dx.doi.org/10.1080/00207450701239459

Reason, J. T, & Brand, J. J. (1975). *Motion sickness*. London, England: Academic Press.

Reed Jones, J. G. (2011). *Prediction and Prevention of Simulator Sickness: An Examination of Individual Differences, Participant Behaviours, and Controlled Interventions* (Doctoral dissertation) Retrieved from http://atrium. lib.uoguelph.ca

Regan, C. (1997). Some effects of using virtual reality technology - data and suggestions. In R. J. Seidel & P. R. Chatelier (Eds.), *Virtual Reality, Training's Future?: Perspectives on Virtual Reality and Related Emerging Technologies (pp. 77-84)*. NATO Defense Research Group. New York, NY: Springer.

Riccio, G. E., & Stoffregen, T. A. (1991). An ecological theory of motion sickness and postural instability. *Ecological psychology*, *3*(3), 195-240. http://dx.doi.org/10.1207/s15326969eco0303_2

Silverman, D. R, & Slaughter, R. A. (1995). *An exploration of simulator sickness in the MH-60G operational flight trainer, an advanced wide field-of-view helicopter trainer* (Report AL/HR-TR-1994-0173). Mesa, AZ: Aircrew Training Research Division, Human Resources Directorate. Retrieved from http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA303619

Stanney, K. M., Hale, K. S., Nahmens, I., & Kennedy, R. S. (2003). What to expect from immersive virtual environment exposure: Influences of gender, body mass index, and past experience. *Human Factors*, *45*(3), 504-520. http://dx.doi.org/10.1518/hfes.45.3.504.27254

Stanney, K. M., Kennedy, R. S., & Kingdon, K. S. (2002). Virtual environment usage protocols. In K. M. Stanney (Ed.), *Handbook of virtual environments: Design, implementation, and applications* (pp. 721-749). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Stanney, K. M., & Salvendy, G. (1998). Aftereffects and sense of presence in virtual environments: Formulation of a research and development agenda. *International*

Journal of Human-Computer Interaction, 10(2), 135-187. http://dx.doi.org/10.1207/s15327590ijhc1002_3

Stoffregen, T. A., Hettinger, L. J., Haas, M. W., Roe, M. M., & Smart, L. J. (2000). Postural instability and motion sickness in a fixed-base flight simulator. *Human Factors*, *42*(3), 458-469. http://dx.doi.org/10.1518/001872000779698097

Stoner, H. A., Fisher, D. L., & Mollenhauer, M. (2011). Simulator and Scenario Factors Influencing Simulator Sickness. In D. L. Fisher (Ed.), *Handbook of Driving Simulation for Engineering, Medicine, and Psychology* (pp. 14.11-14.24).. Boca Raton, FL: Taylor and Francis Group.

Straus, S. H. (2005). *New, Improved, Comprehensive, and Automated Driver's License Test and Vision Screening System*. Boca Raton, FL: ESRA Consulting Corporation. Retrieved from http://www.esracorp.com/AZ559p.pdf

Trick, L. M., & Caird, J. K. (2011). Methodological Issues When Conducting Research on Older Drivers. In D. L. Fisher (Ed.), *Handbook of Driving Simulation for Engineering, Medicine, and Psychology* (pp. 26.21-26.13). Boca Raton, FL: Taylor and Francis Group.

Authors

Eve Paquette is a Researcher at École nationale de police du Québec and a Ph. D. candidate in psychology at Université du Québec à Trois-Rivières. Her current projects focus in three main components: Dynamics of police interventions; Practices and techniques specific to police work; Integration of Information and Communication Technology in police training and practices. Email: eve.paquette@enpq.qc.ca

Danielle-Claude Bélanger is the Director of Développement pédagogique et de la recherche at École nationale de police du Québec. She holds MAs in literature and communication. Her doctoral studies focused on the organizational socialization of teaching personnel. Active in educational research, her interests are competency in French and evaluation of learning. Email: Danielle-Claude.Belanger@enpq.qc.ca