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Driving through the simulated night: A comparison between simulator-based and traditional night driving training

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The current use of simulators in driver training in Norway is very limited. In this study, we explore how a simulator-based night driving course compares to the current course used in Norwegian driver training. The course is very early in the process of obtaining a license and conducted before the learner drivers are allowed to drive themselves. The goal is that the learner drivers acquire knowledge on the subject of night driving. The effects are compared using multiple-choice tests on the night driving curriculum. In the experimental setup, all participants (n = 142) performed both types of training, and they were compared to a baseline group (n = 80). The simulator-based training led to larger improvements in test scores than the current training, regardless of the training order.

Keywords: Driver training, learner drivers, driving simulator, simulator training, night driving, implementing new technology.

1. Introduction

Simulators are often seen as a cost-effective training tool for safety-critical situations (McGaghie et al., 2010; Saghafian et al., 2020; Salas et al., 1998). Their use is common in industries like aviation, nuclear power, petrochemical, medicine, and marine transportation (Klatt et al., 2009; Escobar-Castillejos et al., 2016; Wahl et al., 2020). The use of simulators is also slowly entering a field that has more accidents and a higher death toll than any of the industries mentioned here: driving a standard passenger car (WHO, 2018). Driving simulators improve safety for instructors and learners by allowing safe practice of dangerous scenarios (e.g., children or animals on the road, overtaking) and reduce emissions through repeated training (Sætren et al., 2018). Studies report positive outcomes from driving simulator use (Allen et al., 2007; Casutt et al., 2014; Roenker et al., 2003; De Winter et al., 2009). However, differences in simulator fidelity and performance measures make their effectiveness debated (Blana, 1996; Mullen et al., 2011; De Winter et al., 2007; Wynne et al., 2019).

Simulators have been used in research on night driving, such as driver speeds and attention (Bella et al., 2014; Konstantopoulos et al., 2010; Gillberg et al., 1996). Mikkonen (2007) found better results from simulator training compared to traditional methods for night driving. In Norway, learner drivers do not drive during night lessons (as they have not reached the point in their training where they receive the permission to drive), unlike Finland where they practice in the dark (Mikkonen, 2007).

In countries like the Netherlands, Denmark, Finland, the UK, the Czech Republic, and Slovakia, simulators are integrated into driver training to teach basic driving skills (Fisher et al., 2011; Abele &

Møller, 2018; Mikkonen, 2007). In the Netherlands, simulators can fulfill entire training requirements, though most still take lessons on the road (de Winter, 2009). Simulators are also used for eco-driving and hazard handling for licensed drivers (Beloufa et al., 2019; Wang et al., 2010).

Simulators could be beneficial for advanced skills like risk evaluation and hazard perception, though they are rarely used for this purpose (Abele & Møller, 2018; Pollatsek et al., 2011).

1.1 *Night driving simulators*

There are many technical difficulties that a driving simulator must overcome in order to provide realistic training or conduct realistic experiments (Blana, 1996; De Winter et al., 2007; 2012). In addition, simulating night driving has some added difficulties. The first is the technical difficulty of simulating the effects of darkness. Creating a realistic representation of low levels of illumination (Wood, 2020), the effects of glare (Theeuwes et al., 2002), and blinding (Plainis & Murray, 2002) from bright light sources has proven to be very difficult on a screen or canvas (Wood, 2020; Wood & Chaparro, 2011). Secondly, driving at night is associated with different behavioural patterns than what is seen during the day. This includes increased risk-taking (Clark et al., 2005; 2006), a higher average level of fatigue and sleepiness among drivers (Chipman & Yin, 2009; Lowden et al., 2009), and increased drug and alcohol usage among drivers (Houwing & Stipdonk, 2014). It is often not possible to fully overcome all these difficulties in both training and experiments, leading to limitations in generalizability.

1.2 The Simulator Training in Driver Education Project

The work presented in this article was done as part of a research project called Simulator Training in Driver Education, approved by the Norwegian center for research data (NSD). The project explored simulators' applicability in driver training (Sætren et al., 2019) and includes studies on simulator technology acceptance (Sætren et al., 2020), impacts on driving instructor education (Sætren et al., 2021), and future use scenarios in Norway (Skogstad et al., 2021).

Night driving was identified as a suitable application for simulators due to its mandatory status in Norwegian driver training and seasonal limitations. Simulator training could replace classroom-based instruction, offering an all-year alternative. This study compares simulator-based night driving courses to traditional methods using multiple-choice tests. Gathering behavioural data was not possible as learners are not allowed to drive at this stage. Long-term studies comparing skills and accident rates from different training methods are suggested for future research. Initial results from this study (only the first year of data collection) have been published in an earlier conference proceeding (Sætren et al., 2019).

2. Method

2.1 *Participants*

2.1.1 *Learner drivers – participating in training and experiments*

The participants in this study were all in the starting phase of obtaining their driving licence. This study was conducted as part of the program to educate new driving instructors which means that the learner drivers receive training from both an experienced driving instructor and students in the process of becoming driving instructors. The learner drivers were randomly assigned to an experienced university teacher and driver instructor students. Learner drivers were informed that simulators could lead to symptoms of simulator sickness, that joining the experiment was voluntary, and that they could quit at any time without any repercussions. Informed consent was collected through an informed consent form approved by NSD. The experiment was carried out in two consecutive years, with the new learner drivers at the driving school.

2.1.2 *Baseline*

We wanted to create a baseline on expected knowledge on night driving before starting training. To avoid having the participants complete the same test several times a separate group of people without driving experience completed the tests.

2.2 *Experimental setup*

The participants were divided into two groups by alphabetical order. Group 1 started with the current used training and Group 2 with simulator training. The alphabetical list of names for the two groups were split into two subgroups, which were given the tests (T1 and T2) in opposite orders after the training sessions. After completing the study, all participants had been provided both simulator and current training - and taken both tests (Figure 1).

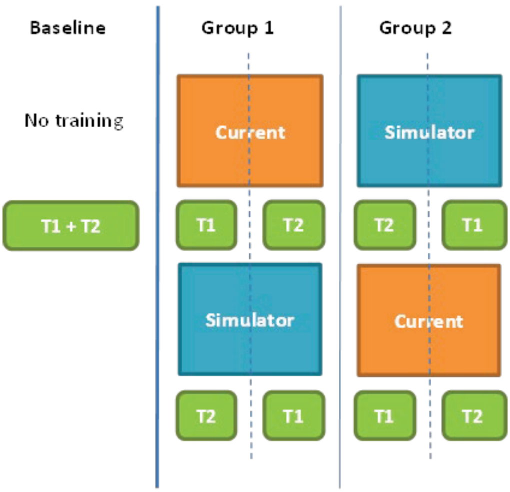

Fig. 1. Research design: Experiment set up.

As the current training is mandatory to obtain a driver's license in Norway, a setup where some participants did not receive the current training was not an option (e.g., use a simple setup where two groups were given different training and completed the same test). The added benefit of this setup was that we could, in addition to comparing the two forms of training, also see if a second round of training influenced test results.

2.3 *Simulator training*

The simulator used in the training was a 2009 ECA Faros EF-X (Figure 2) with three monitors (120° field of view). The simulator uses a close-to-realistic seat, steering wheel, pedals, and gear shift, but it does not include a moving base or haptic feedback.

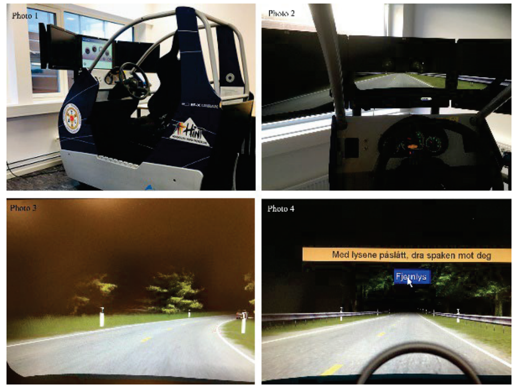

Fig. 2. The ECA Faros EF-X at Nord University used for the simulator training and screens in use. Photo 3 includes instructions (in Norwegian). Photo 1 by G.B. Sætren. Photo 2-4 by Thor Owe Holmquist

The simulator training was developed by driving instructor experts and especially designed for Norwegian night driving. The content is based on the same curriculum as the current training and hence covers the same topics. The training was carried out in the afternoon at Nord University, one learner driver at a time. Before the session started, the learner drivers were given a short explanation by a driving instructor on how the simulator worked and a few minutes to get familiar with the simulator.

The simulator training consisted of six sessions, with a virtual instructor explaining the theoretical concepts and guiding the learner drivers through the different exercises. The six sessions where: 1) Basic skills (use of lights), 2) Meeting a vehicle, 3) To be overtaken, 4) Overtaking, 5) Pedestrians and other dangers, 6) Stopping by the roadside. The learner drivers had to pass one section before they could move on to the next. The simulator training was finished after all six sessions were completed, which took a total of approximately 45–60 minutes. After the training, the learner drivers immediately took one of the multiple-choice tests in an adjacent room, by themselves, with only a student assistant present monitoring the test.).

The current night driving training consists of three elements: classroom theory, an outdoor driving course demonstration, and observational in-car road training (Lovdata, 2017). The theory lesson includes an introduction to the training goals and a summary session afterward.

The training is conducted in the afternoon with groups of learner drivers. Two instructors and two learners occupy each car. The 15-minute drive to the course is followed by a demonstration on light use and visibility. Instructors then drive around the field, explaining visibility and braking distance. This session lasts about 45 minutes.

Following this, the group drives into real-life traffic on a predefined route, discussing elements of the night driving curriculum. The on-road session also lasts 45 minutes, but learner drivers do not perform any driving.

Afterward, a classroom session includes reflections and a summary. Learners then complete multiple-choice tests in a monitored room to ensure individual work.

Multiple-choice tests were used to test curriculum comprehension. The questions developed for this experiment were based on those used in a previous study to measure knowledge on night driving curriculum (Robertsen et al., 2017). A pool of 40 questions where split into two tests (T1 and T2) seeking equal distribution of questions representing the different topics to prevent bias caused by extra knowledge on one topic. Separate tests (T1 and T2, each consisting of 20 questions) were given to the participants after their two trainings (current and simulator). Each question had four different answer options, only one of which being correct. It took about 15 minutes to complete each test. The order of training and testing is presented in Figure 1. Two examples of the questions used are presented below (translated version). The students were asked to select the correct answer by marking the box on the left side.

3. Results

3.1 *Sample*

The total sample (N = 214) had a mean age of 18.00 (*Range* = 16–60), with 100 male (47 %) and 114 female (53 %) participants. The mean age and gender composition of the groups were as follows: baseline 17.58 (n = 80, *Range* = 16–60, 1 missing), 37 males (46 %) and 43 females (54 %); first year of data collection 17.20 (n = 66, *Range* = 17–20), 40 males (61 %) and 26 females (39 %); and second year of data collection 19.28 (n = 68, *Range* = 16–35), 23 males (34 %) and 45 females (66 %). There was a significant gender difference ($t(196.89) = 2.35$, $p = .020$) in total test scores, with women (n = 114, *Mean* = 26.23, *SD* = 5.79) performing better than men (n = 100, *Mean* = 24.20, *SD* = 6.72). There was no significant correlation between age (ranging from 16 to 60, *Mean* = 18,00, *SD* = 4.16) and total test scores ($r(211) = .04$, $p = .536$).

The baseline group had a total mean score of 21.35 (n = 80, *SD* = 5.45), or 10.68 per test, ranging from 8 to 31 out of a possible 40. As expected, the mean baseline score was lower than the mean score after one (n = 134, *Mean* = 13.60, *SD* = 3.02) and two (n = 134, *Mean* = 14.03, *SD* = 3.31) training sessions.

3.2 *Main results*

As receiving both forms of training is an unrealistic scenario in the real world, the most important result is the difference between scores after the first training, where those that had simulator training (*Mean* = 14.24; *SD* = 2.53) significantly ($p < .05$) outperformed those receiving the current training (*Mean* = 12.97; *SD* = 3.51; $t(132) = 2.40$, $p = .018$; Figure 3).

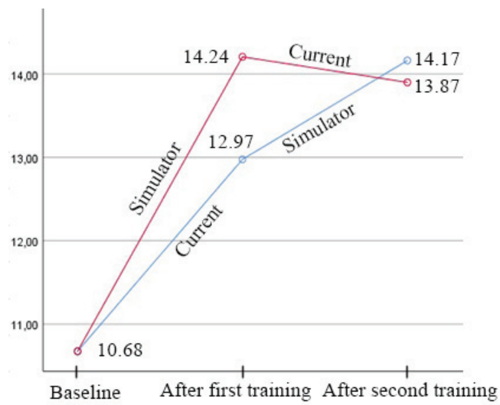

Fig. 3. Estimated baseline and scores after one and two training sessions. Separate lines based on training order.

3.3 *Further analysis*

Further analysis was conducted to find the effect of training regardless of the training order, whether the same effect was found in both years of data collection independently, and the predictive power of training type in predicting the increase in knowledge from the estimated baseline to the first test and from the first to the second test.

To find out the effect of training, regardless of the order it was given in, a repeated measures general linear model, with estimated baseline, test scores after the first training and test scores after the second training as within-subjects variables, and order of training as a between-subjects factors, was used. A repeated contrast was chosen (Figure 3).

Mauchly's test indicated that the assumption of sphericity had been violated (Mauchly's W = .88, $\chi^2(2) = 17.49$, $p < .001$, Huynh-Feldt ε = .91, Greenhouse-Geisser ε = .91). A Huynh-Feldt correction was chosen based on the general rule of thumb of choosing Huynh-Feldt correction when sphericity is violated and ε is above 0.75 (Girden, 1992). The main effect of training was significant (Huynh-Feldt $F(1.81, 239.46) = 61.43$, $p < .001$, $\eta^2 = .32$), as was the interaction effect of training and the order of training (Huynh-Feldt F (1.78, 239.46) = 4.30, $p = .018$, $\eta^2 = .03$). Repeated within-subjects contrasts revealed a significant effect for the test score combined with group membership from baseline to the test after one training ($F(1,132) = 6.10$, $p = .015$, $\eta^2 = .04$) and a significant effect from the test after one training to the test after two trainings ($F(1,132)$ = 8,94, $p = .003$, $\eta^2 = .06$). The groups had very similar, and not significantly different, scores on the final test after completing both forms of training ($\Delta M = 0.30$, $t(131.90) = 0.52$, $p = .602$).

When splitting the groups by order of training and year of data collection (4 groups), the same trend is seen in both years, with the two groups receiving simulator training first showing the largest improvement after the first training, and the two groups receiving the simulator training second showing the largest improvement in the second training (Figure 4). Mauchly's test indicated that the assumption of sphericity had been violated (Mauchly's W = .87, $\chi^2(2) = 17.60$, $p < .001$, Huynh-Feldt ε = .92, Greenhouse-Geisser ε = .89), leading to a Huynh-Feldt correction (Girden, 1992). The main effect of training was once again significant (Huynh-Feldt $F(1.84) = 60.77$, $p < .001$, $\eta^2 = .32$), but the interaction effect of training and the order of training was not (Huynh-Feldt F(5.51, 238.94,28) = 1.59, $p = .156$, $\eta^2 = .04$). Repeated within-subjects contrasts revealed no significant effect from the test score combined with group membership from baseline to the test after one training ($F(3.130) = 2.25$, $p = .086$, $\eta^2 = .05$), but a significant effect from the test after one training to the test after two trainings ($F(3.130)$ = 3.37, $p = .021$, $\eta^2 = .07$). The groups had very similar, and not significantly different, scores on the final test after completing both forms of training (Largest $\Delta M = 0.33$, $F(3,130) = 0.09$, $p = .965$).

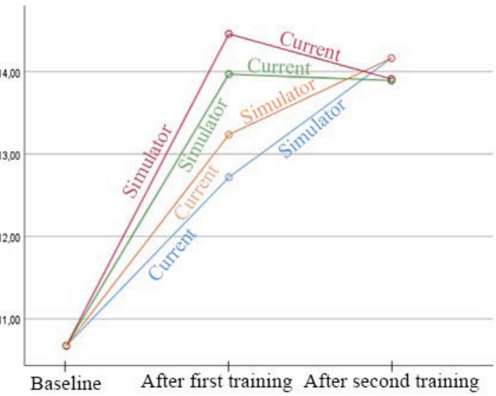

Fig. 4. Estimated baseline and scores after one and two training sessions. Separate lines based on training order and year of data collection. Blue and red lines are from the first year of data collection, the green and orange from the second.

A blockwise multiple regression analysis was used to predict the improvement of each round of training. Age and gender were non-significant and explained 2% ($R^2 = .02$, $p = .348$) of the participants' improvement in test scores from baseline to the first test. Adding the type of training increased the explained variance to 6% ($R^2 = .06$, $\Delta R^2 = .04$, $p = .019$), with the type of training being a significant predictor ($\beta = 0.21$, $p = .019$) of the simulator leading to more improvement than the current training.

Age and gender were non-significant and explained 1% ($R^2 = .01$, $p = .656$) of the participants' improvement in test scores from after the first round of training to after the second round. Adding the type of training increased the explained variance to 7% ($R^2 = .07$, $\Delta R^2 = .06$, $p = .005$), with the type of training being a significant predictor ($\beta = 0.25$, $p = .005$) of the simulator leading to more improvement than the current training.

4. Discussion

In this study, we compared simulator-based night driving training with traditional methods, where learners are passengers in real-life traffic, attend classroom sessions, and participate in outdoor training.

Simulator training outperformed traditional methods in both the full dataset and in each year of data collection. These findings align with Mikkonen (2007), who reported higher test scores from simulator-based night driving training. The training order did not significantly impact overall learning outcomes, as all groups achieved similar final test scores.

Simulator training could replace traditional methods, offering year-round, flexible, and potentially more cost-effective training for learners. It also reduces road time, enhancing safety and minimizing environmental impact. However, implementing simulators as an alternative to traditional night driving training would require updates to Norwegian regulations, as night driving currently mandates the use of an actual car, even though learners only observe.

There are several significant differences between the two training methods making it difficult to pinpoint what is causing the variation in test scores. Current training emphasizes verbal communication and observation, whereas simulators focus on interaction and experiential learning. Simulators provide a hands-on context, allowing learners to experience scenarios like night driving from a driver's perspective. Instructions are integrated with practical experience, fostering active participation, whereas traditional methods may lead to passive learning, particularly in group settings where distractions are common. Simulators also include checkpoints, ensuring learners master each session before progressing.

Simulators offer standardized training, which minimizes variability and ensures consistent delivery of key information. However, traditional training allows instructors to adapt to individual needs, which simulators handle only minimally. While simulator training happens indoors in controlled conditions, reducing discomfort and distractions, traditional training on real roads introduces variability in learning due to differing experiences. Simulators' structured repetition can enhance learning outcomes but lack the reflective dialogue and attitude-building opportunities provided by instructors.

The study had limitations, including a small sample size, young participants, and reliance on multiple-choice tests. These factors, along with varying baseline knowledge, influenced outcomes. Driving instructors in this study were trainees, which might affect the quality but also ensured focused, supervised instruction. While simulator training improved knowledge, its impact on real-world behaviour and accident rates remains unknown.

Simulator training could complement traditional methods, offering benefits like cost efficiency, flexibility, safety, and environmental advantages. However, its broader adoption in Norway requires tailored software aligned with the national curriculum and further research across all training levels. Future studies should also explore behavioural and attitudinal impacts to fully validate simulators as a driver training tool.

5. Conclusion

In the current study, simulator training outperformed traditional training for participants at an early stage in obtaining their driver's license. However, because this study only looked at a small part of a larger curriculum (night driving training), caution should be taken in any generalization of the results to the larger driver training program. Even so, it seems that simulator training, in which learner drivers are participating actively, is a potential alternative, or supplement, to training which is currently done in classrooms, through demonstrations, and while the learner driver is a passenger in the car.

Contributorship

Lindheim led the writing of this paper, Skogstad performed the analysis and Sætren was the project leader of the overarching project. All authors contributed to the conceptualization, data collection and writing of this paper.

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References

Abele, L., & Møller, M. (2018). *Driver training in a simulator. Improved hazard perception.*

Allen, R. W., Park, G. D., Cook, M. L., & Fiorentino, D. (2007). The effect of driving simulator fidelity on training effectiveness. DSC 2007 North America.

Bella, F., Calvi, A., & D'Amico, F. (2014). Analysis of driver speeds under night driving conditions using a driving simulator. Journal of Safety Research, 49, 45.e1-52.

Beloufa, S., Cauchard, F., Vedrenne, J., Vailleau, B., Kemeny, A., Mérienne, F., & Boucheix, J.-M. (2019). Learning eco-driving behaviour in a driving simulator. *Transportation Research Part F: Traffic Psychology and Behaviour*, *61*, 201–216.

Blana, E. (1996). *Driving Simulator Validation Studies: A Literature Review*. Institute of Transport Studies, University of Leeds.

Casutt, G., Theill, N., Martin, M., Keller, M., & JÃ¤ncke, L. (2014). The drive-wise project: driving simulator training increases real driving performance in healthy older drivers. *Frontiers in Aging Neuroscience*, *6*.

Chipman, M., & Jin, Y. L. (2009). Drowsy drivers: The effect of light and circadian rhythm on crash occurrence. *Safety Science*, *47*(10), 1364–1370. https://doi.org/10.1016/j.ssci.2009.03.005

Clarke, D. D., Ward, P., Bartle, C., & Truman, W. (2006). Young driver accidents in the UK: The influence of age, experience, and time of day. *Accident Analysis & Prevention*, *38*(5), 871–878. https://doi.org/10.1016/j.aap.2006.02.013

Clarke, D. D., Ward, P., & Truman, W. (2005). Voluntary risk taking and skill deficits in young driver accidents in the UK. *Accident Analysis & Prevention*, *37*(3), 523–529.

Escobar-Castillejos, D., Noguez, J., Neri, L., Magana, A., & Benes, B. (2016). A review of simulators with haptic devices for medical training. *Journal of Medical Systems*, *40*, 1–22.

Fisher, D. L., Rizzo, M., Caird, J., & Lee, J. D. (2011). *Handbook of driving simulation for engineering, medicine, and psychology.* CRC Press.

Gillberg, M., Kecklund, G., & Åkerstedt, T. (1996). Sleepiness and performance of professional drivers in a truck simulator—Comparisons between day and night driving. *Journal of Sleep Research,* 5(1), 12–15.

Girden, E. (1992). *ANOVA: Repeated Measures.* Newbury Park, CA: Sage.

Konstantopoulos, P., Chapman, P., & Crundall, D. (2010). Driver's visual attention as a function of driving experience and visibility. Using a driving simulator to explore drivers' eye movements in day, night and rain driving. *Accident Analysis & Prevention,* 42, 827–834.

Houwing, S., & Stipdonk, H. (2014). Driving under the influence of alcohol in the Netherlands by time of day and day of the week. *Accident Analysis & Prevention*, *72*, 17–22.

Klatt, K. U., & Marquardt, W. (2009). Perspectives for process systems engineering – Personal views from academia and industry. *Computers and Chemical Engineering*, *33*(3), 536–550.

Lovdata, (2003*) Forskrift om obligatorisk trafikalt grunnkurs før øvingsskjøring for førerkort klasse B.* (Regulations on mandatory courses for license class B). Retrieved November 4, 2019 from https://lovdata.no/dokument/LTI/forskrift/2003-12-09-1461

Lovdata. (2017). *§ 8-1.Generelt om trafikalt grunnkurs*. (General info on basic traffic course) https://lovdata.no/dokument/SF/forskrift/2004-10-01-1339/KAPITTEL_8#KAPITTEL_8

Lowden, A., Anund, A., Kecklund, G., Peters, B., & Åkerstedt, T. (2009). Wakefulness in young and elderly subjects driving at night in a car simulator. *Accident Analysis & Prevention*, *41*(5), 1001–1007.

McGaghie, W.C., Issenberg, B., Petrusa, E. R., & Scalese, R. J. (2010). A critical review of simulation-based medical education research: 2003–2009. *Medical Education*, *44*, 50–63.

Mikkonen, V. (2007). Using simulators to teach driving in the dark as part of driver training. *Report: Finnish Vehicle Administration.*

Mullen, N., Charlton, J., Devlin, A., & Bedard, M. (2011). Simulator validity: Behaviours observed on the simulator and on the road. In D. Fisher, M. Rizzo, J. Caird, & J. Lee (Eds.), *Handbook of Driving Simulation for Engineering, Medicine and Psychology*. CRC Press.

Plainis, S., & Murray, I. J. (2002). Reaction times as an index of visual conspicuity when driving at night. *Ophthalmic and Physiological Optics*, *22*(5), 409–415.

Pollatsek, A., Vlakveld, W., Kappe, B., Pradhan, A., & Fisher, D. (2011). Driving simulators as training and evaluation tools: Novice drivers. In D. Fisher, M. Rizzo, J. Caird, & J. Lee (Eds.), *Handbook of Driving Simulation for Engineering, Medicine and Psychology*. CRC Press.

Robertsen, R., Sætren, G.B., Haukeberg, P., & Sivertsen, H. (2017). Theoretical learning outcome of night driving. A comparison study of traditional real-life training and simulator training. *Risk, Reliability and Safety: Innovating Theory and Practice: Proceedings* *of ESREL 2016* (pp. 1018–1022). Glasgow, Scotland, September 25–29, 2016. CRC Press.

Roenker, D. L., Cissell, G. M., & Ball., K. K. (2003). Speed of processing and driving simulator training result in improved driving performance. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *45*, 218–233. https://doi.org/10.1518/hfes.45.2.218.27241

Saghafian, M., Laumann, K., Akhtar, R. S., & Skogstad, M. R. (2020). The evaluation of virtual reality fire extinguisher training. *Frontiers in Psychology, 11,* 593466.

Salas, E., Bowers, C. A., & Rhodenizer, L. (1998). It is not how much you have but how you use it: Toward a rational use of simulation to support aviation training. *The International Journal of Aviation Psychology*, *8*, 197–208.

Skogstad, M. R., Lindheim, C., & Sætren, G. (2021). Driving Factors for Driving Simulators – A Feasibility Study. *Proceedings of the 31st European Safety and Reliability Conference (ESREL 2021)*, 2581–2588.

Sætren, G. B., Birkeland, T. F., Holmquist, T. O., Pedersen, P. A., Skogstad, M. R., Lindheim, C., & Vaag, J. R. (2020). Accepting driving simulators as a tool in driver instructor training. In P. Baraldi, F. Di Maio, & E. Zio (Eds.), *Proceedings of the 30th European Safety and Reliability Conference and the 15th Probabilistic Safety Assessment and Management Conference*. Research Publishing.

Sætren, G. B., Lindheim, C., Skogstad, M. R., Andreas Pedersen, P., Robertsen, R., Lødemel, S., & Haukeberg, P. J. (2019). Simulator versus traditional training: A comparative study of night driving training. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *63*(1), 1669–1673. https://doi.org/10.1177/1071181319631528

Sætren, G. B., Pedersen, P. A., Robertsen, R, Haukeberg, P., Lindheim, C., & Rasmussen, M. (2018). Simulator training in driver education – Potential gains and challenges. In S. Haugen, A. Barros, C. van Gulijk, T. Kongsvik, & J. E. Vinnem (Eds.), *Safety and Reliability – Safe societies in a changing world.* Proceedings of ESREL 2018, June 17–21, Trondheim, Norway.

Sætren, G. B., Vaag, J. R., Pedersen, P. A., Birkeland, T. F., Holmquist, T. O., Lindheim, C., & Skogstad, M. R. (2021). Driving simulators in teaching and learning. A qualitative study. I A. Strømmen-Bakhtiar, R. Helde, & E. Suzen (Red.), *Supplemental instructions (SI) Volume 1: Digital Technologies*. Waxmann.

Theeuwes, J., Alferdinck, J. W., & Perel, M. (2002). Relation between glare and driving performance. Human factors, 44(1), 95-107.

Wahl, A., Kongsvik, T., & Antonsen, S. (2020). Balancing Safety I and Safety II: Learning to manage performance variability at sea using simulator-based training. *Reliability Engineering & System Safety*, *195*.

Wang, Y., Zhang, W. & Salvendy, G. (2010). Effects of a Simulation-Based Training Intervention on Novice Drivers' Hazard Handling Performance, *Traffic Injury Prevention*, 11:1, 16-24, DOI: 10.1080/15389580903390631

De Winter, J. C. F., de Groot, S., Mulder, M., Wieringa, P. A., Dankelman, J., & Mulder, J. A. (2009). Relationships between driving simulator performance and driving test results. *Ergonomics*, *52*(2), 137–153.

De Winter, J. C. F., van Leeuwen, P. M., & Happee, R. (2012). Advantages and disadvantages of driving simulators: A discussion. In *Proceedings of measuring behavior 2012*.

De Winter, J. C. F., Wieringa, P. A., Dankelman, J., Mulder, M., Van Paassen, M. M., & De Groot, S. (2007). Driving simulator fidelity and training effectiveness. In *Proceedings of the 26th European annual conference on human decision making and manual control, Lyngby, Denmark*.

Wood, J. M. (2020). Nighttime driving: visual, lighting and visibility challenges. *Ophthalmic and Physiological Optics*, *40*(2), 187–201.

Wood, J. M., & Chaparro, A. (2011). Night driving: How low illumination affects driving and the challenges of simulation. In D. Fisher, M. Rizzo, J. Caird, & J. Lee (Eds.), *Handbook of Driving Simulation for Engineering, Medicine and Psychology*. CRC Press.

World Health Organization. (2018). Global status report on road safety 2018. Geneva, Switzerland, WHO.

Wynne, R. A., Beanland, V., & Salmon, P. M. (2019). Systematic review of driving simulator validation studies. *Safety Science*, *117*, 138–151. https://doi.org/10.1016/j.ssci.2019.04.004