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A simulator study: The effect of speed-induced episodes of training in relation to gender differences

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Abstract

Background: Making use of simulators as training devices in not a new topic in research and is already implemented in several fields like laparoscopic surgery and the aircraft industry. A simulator is able to provide students with different training scenarios, without putting them at any risk and can provide all with the same forms of training without being dependent on external events. Therefore, making use of simulators in the automotive domain is on the rise. Additionally, it was investigated that minimally invasive surgery made use of a speed-induced training method that is thought to increase training effectiveness. Speed-induced training episodes are shown to help students to reach their maximum performance. Consequently, the idea aroused to include speed-induced training in a driving simulator and compare that with the effectiveness of accuracy training. Based on previous findings, this research was also conducted to investigate differences in the performance outcomes between men and women.

Methods: To test if speed-induced episodes are more effective than accuracy training, 33 participants were divided into two groups. All the participants had to complete three blocks of training. The instructions for the first and third block were equal for both groups namely, to drive as accurate as possible. The speed group was asked to increase their pace in the second block of training, whereas the accuracy group was asked to follow the same instructions as in block one and three. Women and men were distributed between the two groups to investigate gender differences. Performance was measured based on three variables: Time on task, number of lane departures and number of collisions.

Results: The results indicate that participants drove faster and had less lane departures in the third block of training. No significant difference between the outcome performances of the two training groups were found. Men and women did not seem to be affected differently by any form of training.

Conclusion: The findings did not demonstrate the same results found in prior research. Nevertheless, this does not mean that implementing speed-induced training is inefficient or useless. It means, that future research should focus on adjusting the experimental set-up in a way that generates more speed pressure during the speed-induced episodes of training.

Table of contents

1. Introduction

1.1 Simulator-based training

Nowadays, training with simulators has been proven helpful in a variety of different domains in which human-technology interaction is the focus. In the domain of aircrafts for example, staff showed significant improvements in their performance after training with simulators (Hays, Jacobs, Prince, & Salas, 1992). The training provided by aircraft simulators target those professional skills that are needed to manoeuvre a real aircraft (Roganov et al. 2014). Therefore, in the aerospace domain, simulators are understood as satisfactory training aids (Sturgeon, 2012). Another example of simulator training can be found in laparoscopy. Laparoscopy, also known as minimally invasive surgery, is a surgery method where operating tools and a camera are inserted in the patient’s body through three small incisions. This method is understood as relatively harmless, compared to open surgery but also requires the surgeon to have special skills (Fuchs, 2002). This domain makes use of simulators to train the specific motor skills that are needed for surgery, without bringing along the dangers of real-life surgery for a patient (David, 2018). Advantages found in these two different fields make room for deliberations if other domains would also benefit from using and training with simulators, such as the automotive industry. Hence, this paper focuses on the implementation of driving simulators and their benefits in improving driving behaviour.

The motor skill of driving is learned by most driving-students in a real car in a driving school. Yet, using driving simulators in driving schools would have a positive effect on skill improvement, introduces de Winter et al. (2009). He stresses that using driving simulators in driving schools may strongly improve the students driving skills: driving lessons would be more goal-oriented and therefore more efficient. Research narrows it down to three main advantages that a driving simulator displays over real-life training setting (Bedard, et al., 2010; de Winter, Happee, & van Leeuwen, 2012). First, the simulator provides a safe environment, in which errors and mistakes do not have the consequences that might come along in real life. Second, simulators can virtually display any scenario, created for training. This implies that training sessions are not dependent on for example weather conditions of the country or region students live in. Thus, they can also be tested under the influence of atypical weather conditions, which might not always be accessible in real life. Third, the simulator offers the possibility to confront every driving student with similar or identical scenarios, independently of location and weather (Bedard, et al., 2010). Furthermore, de Winter, Happee, & van Leeuwen (2012), emphasize the fact that a simulator is able to monitor the performance of the driver. Because data can be collected more simply with the help of the simulator, it also becomes easier to make accurate predictions and assumptions about learning behaviour. Taking a step back and reviewing the use of simulators from an ethical standpoint, Underwood, Crundall, & Chapman (2011) highlight the fact that simulators prevent driving students from being exposed to high risks. Due to simulators, drivers are not exposed to hazards such as collisions in traffic situations that are hard to overlook. While being safe, the driver still benefits from the challenges of the virtual scenario. Besides the advantages simulators provide for their users, the automotive industry also benefits from the implementation of simulators in driving schools. Compared to real life driving lessons, simulator lessons reduce testing costs (Sætren, et al. 2018).

Challenging however, to guarantee a realistic setting that reflects a real-life experience, is the technology. The technology should integrate user interaction with the scene and the scenario, without lacking credibility (Cremer, Kearney, and Papelis, 1996). In this respect, research suggests that even though driving a simulator is not the same as driving a real car, the behaviour displayed in both systems are nevertheless resemblant (Bedard, et al., 2010).

1.2 Speed-induced training episodes

Through this study we will investigate how, by means of a driving simulator, driver's learning behaviour can be enhanced. Based on information obtained in the domain of minimally invasive surgery, reducing the time spent on task (ToT) can be effective. The reduction of ToT namely helps to reach individuals maximum performance. Characteristic of such "speed episodes" is the learning of new motor sequences at high speed regardless of possible errors (Weimer, 2019). Weimer (2019) also highlights that episodes in which the task at hand is pressured by time and the possibility of the individuals to make errors without causing real-life harm, has shown to improve learning and demonstrate lower rates of damage. It might not seem reasonable to transfer the results obtained by minimally invasive surgery to a domain that focuses on vehicle manoeuvring. Nevertheless, research from the domain of air transportation certainly shows similar results. A flight simulator study provides additional proof that paced-induced episodes are especially beneficial in learning (Hays, Jacobs, Prince, & Salas, 1992).

Taking a step back and broadening the look of learning in general, Price-Mitchell (2011) emphasizes that also children learn through making errors and mistakes. Human nature shows that making mistakes challenges the children to try different approaches and motivates them to improve their performance. This study suggests that implementing a phase in which error making is allowed or even desired, can have beneficial effects on the learning behaviour of the participants and can improve their performance on simulator training. The question arises: do "speed episodes" lead to a significant improvement in the performance of participants? It is hypothesised that episodes of speed induction, in which errors do not have consequences, will lead to better performance.

1.3 Gender differences in driving behaviour

Studies show a difference in the tendency of risky driving between females and males. The results show that males tend to drive three times riskier than females and are generally more engaged in unsafe behaviours while steering a vehicle. Besides the general tendency to strain traffic regulations, a major factor of violation lies in the exceedance of speed limits in male drivers, especially in adolescent ones (Rhodes & Pivik, 2011; Harré, Field, & Kirkwood, 1996). Based on this information and considering the purpose of this study, namely, to see what effect "speed episodes" have on the learning progression in driving, it becomes interesting to also investigate if this effect might deviate between females and males. It is therefore justifiable to ask if male participants are more prone to benefit from the "speed episodes" than females.

As previously established, a driving simulator is only a representation of reality and by no means reality itself. Despite that, simulators are still considered useful instruments when comparing real-life with simulated driving behaviour (de Winter et al. 2009). Taking these aspects into account, one can presume similar differences between male and female differences in a simulator as analysed on real roads. Since the "speed episodes" aim at driving at high speed regardless of the consequences, and are expected to improve learning, one can expect that such episodes might have higher effects and better outcomes for male drivers than females. This assumption arises because the male participants might take more advantage of the speed episodes than the females, since they generally tend to drive faster. Consequently, it is hypothesised that the "speed episodes" improve males´ performance more than females´.

2. Methodology

2.1 Participants

The study was conducted with 42 participants. A great part of the participants was recruited personally by the two researchers whereas the rest was invited via the SONA system provided by the University of Twente. The participants that were gathered by the latter method received 2 credits as a reward of their participation. Out of the tested 42 participants, 9 participants dropped out due to motion sickness, experienced in the driving simulator. The original sample size of 42 participants was composed of 24 females and 18 males but decreased to a total of 33 participants, due to the 9 participants who withdrew from the study. The final sample consisted of female (n=18) and male (n=15) participants ranging from the age of 17 to 25 years (m=19.667; SD=1.882). The participants had different national backgrounds with the majority coming from the Netherlands (*n*= 24), whereas the rest were recruits from Germany (*n*=5) and others (*n*=4) coming from Romania, Lithuania, and China. In the dataset of 33 participants no significant outliers were found.

The participants were divided into two different conditions of training. The first group was trained with speed-trials (9 females; 8 males). The second group joined the accuracy-trails with a similar division (9 females; 7 males). All participants were told that they could withdraw from the study at any time without further justification. The only exclusion of data was due to an incomplete data set of individuals who felt motion sick during the experiment.

2.2 Task

The participants were divided into two groups. One group receiving “accuracy training” and the other “speed training”. The participants were told that they would have to complete 3 blocks with 12 trials each. The first 12 trials were equal for both groups. The participants had to drive as if they would drive on a normal road. The main task in the first block was to concentrate on driving well, rather than fast. All participants were instructed to drive as accurate as possible and to keep collisions to a minimum, while trying to stay in the right lane. They were told that all these mistakes would be counted by the researchers. Furthermore, they were informed that their time would be measured for every trial. The participants receiving accuracy training had the same instructions for all continuing blocks of training (block 2 and block 3). The participants who were part of the speed training, had different instructions for block 2. They were asked to drive as fast as possible in the 12 trials of the second block, without caring about making mistakes and errors. They were told that hitting an object or departing from the lane would be ignored. The last block however was again the same for both groups, namely, to drive as accurate as possible.

2.3 Measures

The information gathered by the three different parameters (ToT, number of lane departures and number of collisions) in the different blocks was expected to show possible improvements of the participants. Improvements were awaited between the first and the third block of training as well as in the performance between groups.

2.3.1 Time on Task (ToT)

The time on task (ToT) was measured in seconds and was taken by two different sources (simulator and manual stopwatch). After collecting the time via two sources, the mean was calculated for all 36 trails per participants.

2.3.2 Number of Lane departures

To determine how accurate the participants drove, the number of lane departures were counted during the accuracy trials, which was undertaken by the two researchers. Again, to get the most accurate results, the mean of the two values were taken to reduce possible errors. Researchers counted a departure, every time the participants drove over the left road marking.

2.3.3 Number of Collisions

Drivers´ accuracy was evaluated based on the number of collisions. The number of collisions was counted manually by the two researchers to get an accurate mean for all accuracy trials. Every time a participant drove into objects on the road (traffic lights, buildings, or trees) or bumped into the sidewalk, a collision was counted. After colliding, the car could flip over and the participant needed to hit the brake, to bring the car back into the correct position. After that, the participants were able to continue and finish the trial. Therefore, colliding had direct consequences for the ToT.

2.4 Driving simulator and environment

The driving simulator consisted of a steering wheel from Logitech and a PlaySeat (Figure 1). The speed of the simulator was regulated by pedals for braking and accelerating. The simulator was provided with an automatic gear system. The distance between pedals and seat was manually adjustable for each participant. The environment was presented to the participants via the Varjo VR-2 Pro headset.

Figure 1 Driving simulator

The surroundings were created in Unity Hub and consisted of buildings, trees, and roads. Barricades were blocking the way so that only one specific route was accessible for the drivers. No pedestrians or other road users were implemented. The route the participants drove, was the same for all three blocks of training (Figure 2). The accuracy and speed training differentiated in the way that for the speed training all buildings and trees were removed from the environment.

Figure 2 Experiment-Route

2.5 Procedure

The participants were asked to come to the campus of the University of Twente. The windows of the room in which the experiment was conducted, were constantly open to allow fresh air to fill the room. This was done to prevent occurrence of motion sickness as well as to comply to Covid-19 requirements. After arrival, the participants received a consent form (Appendix A) that needed to be signed to guarantee that they understood and agreed on the terms of the procedure. The informed consent was followed by a pre-questionnaire (Appendix B) that asked for relevant information, like the demographics of the participants as well as personal driving experience. After that they sat down in the simulator-seat to become acquainted with the pedal- and steering wheel system of the simulator. The participants were asked to adjust their seat. Then, they were helped with positioning the Varjo VR-2 Pro headset comfortably. The participants were divided into two different groups, both starting with a small practice trial, followed by three blocks of main trials. The practice trial, with a duration of a maximum of three minutes, was supposed to help the participants to get used to the headset and setting. They were asked to test accelerating and braking with the driving simulator and to drive around corners to identify any problems with motion sickness. If participants felt motion sick at this point, they were asked to take off the VR glasses and drink some water. If the participants then decided to try again, they did, otherwise the experiment was stopped.

After the practice trial, the participants were instructed with their task for the first block (see section 2.2). The experiment was then started, and the first 12 trials were only interrupted when a participant felt sick or unwell. Then the experiment was paused and only continued if the participant felt able to do so. After each round the researchers noted the measures for the trial and immediately continued with the next round. At the end of the first block, the participants were asked to take off the VR-glasses to prevent occurrence of motion sickness and were offered water to drink. After a short break and if the participants felt good to continue, the next block was started (accuracy or speed). During these 12 trials the same procedure was executed as during the first block. However, for the participants in the speed training, no lane departures and collisions were counted. Table 1 provides an overview of the characteristics of the two experimental conditions (accuracy and speed). Again, after 12 trials the experiment was paused, and the participants were able to rest. The last block was carried out like the first block for both groups. After the last trial, the participants could again drink something if they wanted to and stand up from the seat and walk around. They were told to take time to get adjusted to the real world, after wearing the VR glasses for 60 to 90 minutes. When the participants felt ready to leave, they were thanked for their participation in the experiment. The simulator was disinfected after each participant and the new protection paper was put on the VR-glasses.

Table 1 Overview of Accuracy- and Speed training

Condition 1: **Accuracy training**	Condition 2: **Speed training**
Practice trial (max. 3 minutes)	Practice trial (max. 3 minutes)
1. Block Accuracy1	**1. Block Accuracy1**
# trials/block: 12	# trials/block: 12
Instruction: You will now drive 12 trials. Please drive as you would on a normal road in real life and try to stay in the right lane.	Instruction: You will now drive 12 trials. Please drive as you would on a normal road in real life and try to stay in the right lane.
small break	small break
2. Block Accuracy2	**2. Block Speed1**
# trials/block: 12	# trials/block: 12
Instruction: You will again drive 12 trials. Please drive as you would on a normal road in real life and try to stay in the right lane.	Instruction: Again, you will drive 12 trials, but this time we are interested in your driving behaviour in an environment where the risk of collision is removed, and speed should be induced.
small break	small break
3. Block Accuracy3	**3. Block Accuracy2**
# trials/block: 12	# trials/block: 12
Instruction: You will again drive 12 trials. Please drive as you would on a normal road in real life and try to stay in the right lane.	Instruction: You will again drive 12 trials. Please drive as you would on a normal road in real life and try to stay in the right lane.

2.6 Data analysis

The program SPSS was used for the data analysis of this research. Descriptive statistics and frequency tables were computed for gender, age, and nationality. From the three dependent variables ToT, lane departures, collisions the mean score was computed to compare them. To identify how much variance in the sample could be explained by the speed training and gender, three individual mixed factor ANOVA tests were conducted. Before the ANOVA tests were implemented, the appropriate assumptions that needed to be met were tested. Finally, post hoc tests were conducted to test for significant differences between the blocks.

3. Results

Before conducting a two-way analysis of variance (ANOVA), several assumptions must be met. The dependent variables (ToT, number of lane departures, number of collisions) must be measurable on a continuous level whereas the independent variables (gender, condition) must be categorical. Furthermore, the dependent variables should be normally distributed, which is not fulfilled for all combinations of the two independent variables. The Levene's test nevertheless showed no significance, suggesting that the variances of the variables between the groups are approximately equal. The Shapiro-Wilk test results detected that the dependent variable ToT is normally distributed ($p > .05$). Analyzing the normality of the two remaining dependent variables (number of lane departures and number of collisions) resulted in a type 1 error. Research suggests however, even though the null hypothesis is rejected, and the assumptions of normality are not met, the F-test still shows valid results (Alarcón, Arnau, Bono & Bendayan 2017). Despite not meeting all assumptions, but considering the robustness to non-normality, it can be concluded that running a two-way repeated measures ANOVA is still a solid choice. MANOVA is not chosen for analysis, since the dependent variables show signs of multicollinearity, with a score being above .80 (Kim, 2019). Therefore, two independent ANOVAs are conducted even though the research investigates several dependent variables.

3.1 Overall effect of training

The ANOVA provided insight into the difference between the performance of participants before and after training (speed/accuracy). Comparing the mean scores of ToT (in seconds) of the first and the third block of training shows an improvement in performance. The average time it took the participants to complete the 12 trials in the first block was 57.156 seconds (*SD*= 29.11). However, the third block was completed in an average time of 53.268 seconds (*SD*= 26.998). These results indicate that participants from both groups completed the 12 trial of block three on average significantly faster (F (1,40) = 34.629, $p < .001$) than the trials of block one (see Figure 3).

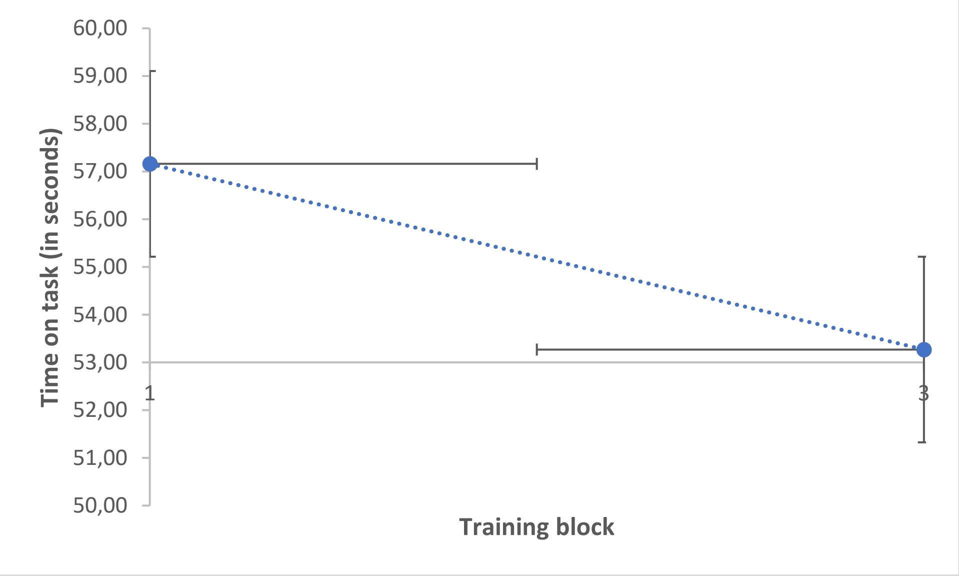

Figure 3 Mean difference of ToT between block 1 and block 3 of all participants

The ANOVA indicated a decrease in number of lane departures from the first to the third block of training (see Figure 4). (Accuracy block 1 number of lane departures (*Acc1Nld) M*= 2.326, *SD*= 1.579; Accuracy block 3 number of lane departures ((*Acc3Nld) M*= 1.774, *SD*= 1.303)). This positive effect of training indicates that significantly less lane departures were made in the third block than in the first block (F (1,32) = 8.576, p=.009).

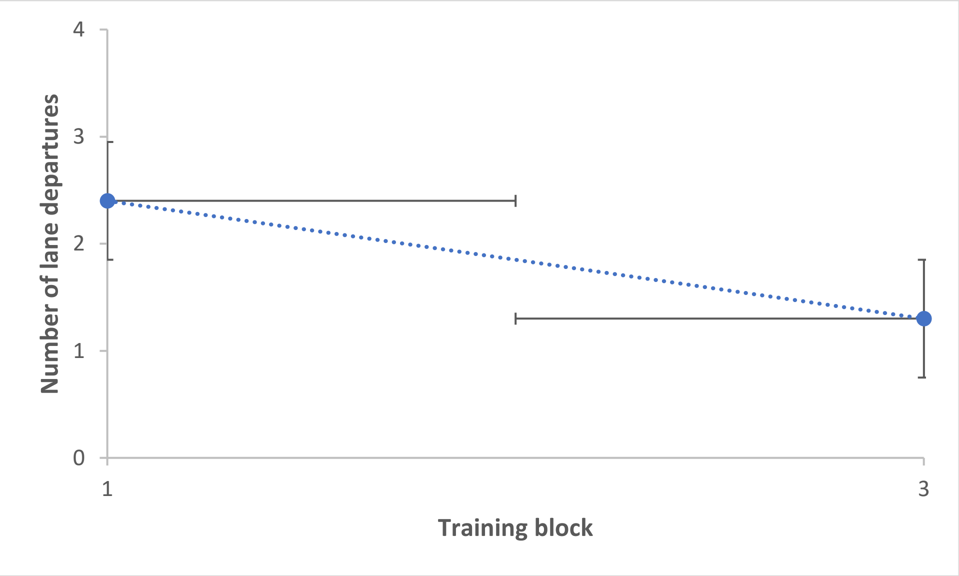

Figure 4 Mean difference of Number of lane departures between block 1 and block 3 of all participants

The two means of accuracy block 1 number of collisions (*Acc1Nc) M*= .4802, *SD*= .54202; accuracy block 3 number of collisions ((*Acc3Nc) M*= .4091, *SD*= .55716) indicated no significant difference between groups. The number of collisions of block one did therefore not significantly decrease in block three due to training (*F* (1,32) =.802, *p*= .377).

3.2 Differences in performance outcomes between Speed and Accuracy

The ANOVA showed that the mean of ToT in the third block of the participants from the accuracy training was 66.047 seconds (*SD*= 5.69), whereas the participants from the speed training needed an average of 66.309 seconds (*SD*= 5.404) to complete one trial. This result was found to be non-significant (*F* (1,32) = .018, *p*= .893) and suggests that neither the accuracy nor the speed training improved the performance on ToT.

The mean number of collisions between the two groups in the third block were .302 collisions (*SD*= .289) for the participants of the accuracy training and .510 collisions (*SD*= .721) for the participants of the speed training. Nevertheless, this difference was found to be non-significant (*F* (1,32) = 1.156, *p*= .291). Therefore, if the individuals received accuracy or speed training, had no impact on their number of collisions.

Looking at the mean of the number of lane departures in the third block, it can be emphasized that the difference is low. Accuracy training had an outcome of 1.846 number of lane departures (*SD*= 1.644) on average per trial whereas the speed training had 1.705 (*SD*= .923). The ANOVA suggests that this difference is not significant (*F* (1,32) = .094, *p*= .762). It can be concluded that neither the speed training nor the accuracy training had a significantly greater effect on decreasing the number of lane departures. Neither speed nor accuracy training led to differences in performance outcomes regarding any of the three dependent variables.

3.3 Differences in performance outcomes between female and male participants

Analyzing the mean differences in ToT with ANOVA of block three shows that the female participants took an average of 55.251 seconds (*SD*= 25.738) to complete one trial in the third block, compared to the males who took 47.556 seconds (*SD*= 31.864). Results identify a non-significance of the outcomes of the two groups regarding ToT (*F* (1,31) = .572, *p*= .455).

While male participants seem to drive faster than females, they also seem to drive more recklessly. Female scores for number of collisions per trial of the third block were on average .245 (*SD*= .297) compared to the males who collided .667 times on average per trial. However, although the data may seem to suggest a difference between the two groups, this only approached significance (*F* (1,24) = 3.237, *p*=.085). The mean difference in the number of lane departures for females and males per trial of the third block was found to be non-significant (*F* (1,24) = .125, *p*= .727).

3.4 Differences in performance outcomes between Speed and Accuracy regarding Gender

Looking at the differences between the speed and the accuracy training for both males and females it can be said that it took the female participants of the accuracy training 44.387 seconds (*SD*= 33.341) to complete one trial, whereas it took the males 48.953 seconds to complete one round (*SD*= 34.506). In the speed training however, the male participants took 46.16 seconds (*SD*= 31.695) and the females 66.11 seconds (*SD*= 5.527) to reach the finish line. Comparing the ToT for the male participants of both the speed and the accuracy training, indicates no difference (see Table 2). The same holds for the results for the female participants of both groups. All results are non-significant (*F* (3,31) = 1.095, *p*= .367).

Table 2 Mean scores of block 3

Dependent variable	*Acc3ToT*		*Acc3Nc*		*Acc3Nld*	
GenderCon	*M*	*SD*	*M*	*SD*	*M*	*SD*
FemaleAcc	44.3867	33.3409	0.3333	0.42636	1.8833	1.14418
FemaleSpeed	66.1144	5.5269	0.1856	0.17664	1.9544	2.01067
MaleAcc	48.9532	34.50623	0.75	1.1807	1.78	1.5393
MaleSpeed	46.1586	31.69526	0.584	0.42459	1.65	0.43892

Note: Mean scores of the three dependent variables (ToT, number of collisions and number of lane departures) in the third block of training for all combinations of speed and accuracy and female and male.

The number of collisions of the third block show that the difference in speed and accuracy training is non-significant just as the between-subject effects (*F* (3,24) = 1.143, *p*= .355). Neither females nor males showed a difference in number of collisions. Additionally, the two forms of training did not show a stronger effect in either of the two gender groups. Lastly, the average number of lane departures in the third block did not show a difference between speed and accuracy and was therefore found to be non-significant (*F* (3,24) = .047, *p*= .986).

4. Discussion

4.1 Aim of research and important findings

The main goal of the study was to determine if training with driving simulators, mainly implementing speed episodes, can have a significant effect on performance. The second goal was to see if females and males benefit differently from this form of training.

The results indicate that training had an overall effect on performance, regardless of which training method was used. A significant difference of effect between the two training methods was not found, therefore it cannot be concluded that this improvement was generated by either speed or accuracy training. The study demonstrates that a difference between female and male drivers in outcome performance was also not identifiable. When taking both factors, training method and gender, into consideration, the research did not find any significant results in-between those groups.

4.2 Limitations and future research

Since the motivation for the study is based on results found in real life driving behaviour converted into simulator-behaviour, one must consider the fact that results might lack significance due to the difference between simulated and real-world. This might be one of the reasons the results obtained in this research differ from results of past investigations. If simulators are used as means of helping devices in driving schools, it is reasonable to state that the driving experience should be equal to driving in a real car. A reason to assume that the driving simulator used in this experiment did not provide the full experience of reality, is the fact that 9 participants had to stop the simulations due to feelings of motion sickness. Consequently, future research should focus on conducting research in simulators that come as close to reality as possible.

Moreover, since the simulator was not able to count the number of lane departures and collisions, some discrepancies between this experiment and past research might be due to human error. To minimize possible biases, the two researchers decided to count individually and use the mean scores as a basis for analysis. However, not all mistakes can be prevented, that might have caused some fluctuations in the results. Future investigation should consider implementing a counting device into the system used for research.

The results of the three dependent variables in the first and last block of training indicate that the participants decreased the time it took them to complete one trial by an average of 3.89 seconds. The participants did also depart significantly less often from the lane in the third block compared to the first, which indicates an improvement in control over the vehicle. However, the number of collisions did not improve over the course of training, indicating that both training methods were not effective in eliminating collisions. Overall, these results indicate that the participants drove faster, while being able to hold the lane more precisely which demonstrates more control at higher pace. Since the collisions did not decrease, the participants seemed to make the same number of severe mistakes driving at higher speed, implying that both training methods are not effective at eliminating these mistakes. The analysis conducted in this paper mainly focused on comparing between group designs and their performance outcomes, but additionally focusing on individual development might have been more informative about the effectiveness of training. When looking at the overall effect of training, it was concluded that the population did significantly improve its ToT and reduced the number of lane departures after any form of training. However, these results do not necessarily identify that this effect was present for every participant. Since only the means of the first and last block of training were compared, it was assumed that everyone improved after training. Nevertheless, it could have happened that for example the performance of several females of speed training had worsen from block 1 to block 3. If the scores of the remaining participants from the speed episode were able to compensate for these female participants, namely that the overall score of performance still showed improvement from block 1 to block 3, then this error would have gone unnoticed. Looking at the training outcomes of block 3 is helpful for identifying if an individual can perform at a certain level. For example, this would be useful in driving schools, to decide if a driving student is ready to take the driving test. The outcome performance would then indicate if a student is able to perform at that certain level that is required to pass the test. However, to make training even more efficient in the future, it would be advisable to lay more focus on the individual development of the participants, in form of learning curves. As a result, more precise information about individual reactions to training, any form of fluctuations and plateaued performance can be retrieved.

Jiménez-Mejias et al. (2014) argue that male individuals tend to drive faster than females. Moreover, a paper shows that implementing speed-induced episodes into training is found to increase performance (Weimer, 2019). When connecting these two sources of information, one might agree with the hypothesis that males will benefit more from training with speed episodes than females and therefore also have better performance outcomes. The results gathered from the conducted research however presents no such effect. Contrary to the hypothesized association, male participant did not show a significant difference compared to females, and additionally no difference between speed and accuracy training was found for males and females. The results do also not fit the theory that females tend to engage in less risky and accidental driving behaviour than males. No significant difference in the number of collisions and number of lane departures was found for either gender group. Consequently, claims made by prior studies, which were taken as grounds for this research, were not observed in these results. A possibility is, that the experiment would have shown similar results when the participants received not only a verbal instruction from the researchers to increase their speed in the second block of speed training. Although the participants were instructed to drive fast, during that block of training regardless of possible collisions and lane departures, other forms of time pressure cues might have increased the effect of speed-induced learning more. Implementing cues such as a countdown or stopwatch could be more efficient in triggering the participants to drive as fast as they can. Consequently, differences between the two groups of training could have been greater as well as the differences between gender.

Finally, the study itself was easy to implement and due to its simple setup, a good way to get an overall idea of how training influences outcome performance. Even though this research was conducted with a small sample size and did not lead to many of the hypothesized results, the findings allow us to make assumptions about how future training settings should be constructed and what might influence their outcome. The fact that VR-glasses were used instead of screens provided a more realistic feeling of driving. The equipment in general (seat and steering wheel) was very similar to features of a real car. The fact that an overall training effect was found, emphasizes that this research should be acknowledged.

5. Conclusion

This paper delt with the motivation to implement speed-induced episodes into drivers training by using a simulator. Past research indicates that this form of training has been proven to be effective in other domains like the aerospace industry and laparoscopic surgery. Furthermore, gender differences were put into focus to identify any existing discrepancies in training effects between men and women. It was expected that speed-induced training is more effective than accuracy training, and more beneficial for men than for women. The results of the ANOVAs indicate that the participants did improve their skills over the course of training but did not display better outcomes from one training method compared to the other. Additionally, no difference between the two genders were found. However, this does not imply that speed-induced training is inefficient or redundant, but that future research should focus on adjusting the speed-induced training in a way that significantly differentiates it from the accuracy training.

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Appendices

Appendix A

Informed Consent Form

'Driving simulator'

I give my consent to participate in the Driving Simulator Study that investigates individual learning behaviour and is run by the department of Psychology at the University of Twente in Enschede.

I have been informed about the nature of the experiment. I understand that my participation is voluntary. I may withdraw from the study at any time without further justification. I have the right to a debriefing about the general results of the study and I may obtain my individual results upon request. I give my consent knowing that all aspects of my participation will remain confidential and that I will not be subjected to any harm or deception.

I understand that the experiment has potential benefits in understanding individual learning behaviour and processes that might facilitate these. The aim of this study is to comprehend how humans interact with technology and how this interaction can be improved and optimized. The results might provide a basis for future studies in the field of Human Factors and Engineering Psychology.

____________________	____________________
Name of Participant	Date

____

Signature of Participant

Appendix B

Pre-questionnaire
We are happy that you want to participate in this study. Note that all information you provide within this questionnaire will only be linked to your participant number (not your name) and no third parties will have access to your information.

Demographic information

1. What is your age?
   ____

2. What is your gender?
a. Male
b. Female
c. Other: _____________________
3. What is your nationality?
. Dutch
a. German
b. Other: ________________________

Driver experience

1. Do you have a driver's license?
   1. Yes, for how long?_____________________________
   2. No
- If Yes: go to question 3
- If No: go to question 2

2. Have you ever had a driving lesson?
a. Yes
b. No
- If Yes: go to question 3
- If No: this is the end of the questionnaire

3. How often do you drive? Please give an indication how much you drive per week and per month
___________ times a week
___________ times a month

4. Do you own a car? (Note: this car should be yours, not the car from your parents)
a. Yes
b. No

5. Have you ever driven in other countries than the country you are from?
a. Yes, which countries? ____________________________________
b. No.

6. Please tick all situations in which you have driven:
a. Heavy rain
b. Stormy (very strong winds, heavy rain, hail, etc.)
c. Snow (both snow on the road and snowing)

d. Icy/slippery roads
e. Thick fog

7. Do you have a crash-history?
a. Yes
b. No
c. Not willing to share

8. Do you tend to keep the speed limit?
a. Yes, perfectly
b. No, I mostly go somewhat faster
c. No, I mostly go somewhat slower
d. Not willing to share

9. What is the highest speed you have driven by yourself?
____