The effectiveness of an online driving simulation for adolescents without driving experience

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Abstract

According to most literature gaining driving experience results in a safer driving style and less traffic accidents. With the help of an online driving simulation developed by Green Dino, students are able to practice driving on their own computer. However, the effectiveness of this online driving simulation was still unclear. An experiment with 42 participants between 15 and 25 without driving experience was conducted to examine if the online driving simulation could improve driving skills. Participants performed a driving test on a mid-level driving simulator as a pre- and posttest and in between they followed either the online simulation or an online game as a control condition for 35 minutes. Results showed that the increase in overall driving skills did not significantly differ between the two groups. From all 10 measurements only ‘fluent braking’ showed a large effect. Furthermore, the driving skills that could potentially be influenced by the online simulation are the short-range process of smooth steering, the starting point of braking and adjusting the speed when approaching an intersection. Adjustments to the study are needed to confirm whether the online simulation is ineffective or that it requires more practice hours to improve perceptual motor skills.

Volgens een groot deel van de literatuur resulteert het opdoen van rijervaring in een veilige rijstijl en minder verkeersongelukken. Met behulp van een online rijsimulator, ontwikkeld door Green Dino is het voor leerlingen mogelijk om rijervaring op te doen op hun eigen computer. Echter, de effectiviteit van deze online simulatie was nog onbekend. Een experiment met 42 deelnemers tussen de 15 en 25 zonder een rijervaring is uitgevoerd om te onderzoeken of de online rijsimulatie de rijvaardigheden kan verbeteren. Deelnemers voerden een rijtest uit op een rijsimulator als een voor- en na-test waartussen zij ofwel de online simulatie volgden ofwel een online spel speelden voor 35 minuten. De resultaten lieten zien dat de toename van rijvaardigheden niet significant verschilde tussen de twee groepen. Van de 10 variabelen liet enkel ‘vlot remmen’ een groot effect zien. De vaardigheden die potentieel beïnvloed kunnen worden door de online rijsimulatie zijn het korte-afstand proces van vloeiend sturen, het startpunt van het remmen en het aanpassen van de snelheid bij het benaderen van een kruispunt. Aanpassingen aan de studie zijn nodig om vast te stellen of de online simulatie ineffectief is of dat er meer trainingsuren nodig zijn om de perceptuele motorische vaardigheden te verbeteren.

ACKNOWLEDGEMENT

I would first like to thank Green Dino for giving me the opportunity to conduct this research and providing me with all the material I needed, including two driving simulators. In particular my external supervisor Jorrit Kuipers, who was very enthusiastic about the topic and provided me with a lot of knowledge and material about driving simulators. Also several employees played a big role by helping me with the right settings on the driving simulators. I would also like to thank my first supervisor Willem Verwey for providing me with helpful feedback throughout the process and my second supervisor Martin Schmettow for his extra deliberation about the statistical analysis. Finally, I am grateful to everyone that took the time and effort to participate in the experiment.

TABLE OF CONTENT

1. Introduction

1.1 Young novice drivers

Young novice drivers have a relatively high chance of being involved in a traffic accident per driven kilometer (Pollatsek, Vlakveld, Kappé, Pradhan & Fisher, 2011; Pradhan, Pollatsek, Knodler & Fisher, 2009; McKnight & McKnight, 2003). The highest risk occurs during the first six months or 1000 kilometers of driving independently (Meyhew, Simpson & Pak, 2003). Young drivers have a high tendency for reckless behavior like sensation seeking and risk taking and there is no balance between cognitions and emotions, which could result in a bad recognition of other drivers' intentions (Glendon, 2011). Gregersen and Bjurulf (1996) presented a model of young drivers' accident involvement, showing the influence of learning processes, individual preconditions and social impact on driving behavior and accident involvement. They emphasized that experience is important for the skill acquisition process in which behavior patterns are automated and the mental workload is reduced. The model describes two clusters of causes: experience-related (learning process) and age-related (individual and social circumstances). Additionally, other studies found that the higher crash rate of young novice drivers is probably more defined by the lack of experience than by age specific features (McKnight & McKnight, 2003; Petzoldt, Weiß, Franke, Krems & Bannert, 2013; Vlakveld, 2005). Experience is therefore an important determinant for safe driving behavior. Research of Clarke, Ward, Bartle and Truman (2006) showed that loss of control on curves and accidents in darkness are a particular problem for young drivers. When driver experience increased, cross-flow (turning left onto or off a major road) accidents showed the quickest improvement. Experience with cross-flow turns is thus an important factor to take into consideration to reduce traffic accidents among young drivers.

Literature about self-assessment of driving skills shows that young drivers estimate their driving skills as being better than the average or than experts (Amado, Arikan, Kaça, Koyuncu & Turkan, 2014; Horswill, Waylen & Tofield, 2004) and underestimate their chances to be involved in an accident (McKenna, 1993: Finn & Bragg, 1986; Deery, 1999). This over-estimation of driving skills is mainly caused by a 'positive-self' bias rather than a 'negative-other' bias (McKenna, Stanier & Lewis, 1991). Molina, Sanmartín and Keskinen (2013) pointed out that overconfidence is found to be an important explanatory factor behind young drivers' accident involvement. If drivers overestimate their own skills they get overconfident and could adopt a more reckless driving style, which will cause risky and dangerous situations. Self-evaluation, self-assessment and self-awareness are just as important as knowledge, skills and risk increasing factors in order to be a safe driver (Paräaho Keskinen, and Hatakka, 2003).

1.2 Online driving simulator

Recently Green Dino developed an online driving simulation in which students can gain driving experience by driving in a virtual environment on their own computer with the use of a mouse and a few keys on the keyboard. Green Dino BV is a company, situated in Wageningen the Netherlands that works on the development and production of driving simulators and other virtual reality applications. The virtual car can be started by pressing the space bar on the keyboard. Thereafter, pushing the mouse forward results in acceleration and pulling the mouse backwards functions as the brake. It resembles an acceleration and brake pedal, the level of acceleration or braking depends on how far the mouse is pushed forward or pulled backwards. The mouse also functions as a steering wheel by moving it left or right and the turn signals are activated by clicking the left or right button on the mouse. By pressing the right and left arrows on the keyboard the view in the right or left mirror is shown on the screen. Viewing behavior can therefore also be practiced in the simulation. The online driving simulation gives direct feedback on actions and will mention or show what actions were not executed correctly, by for example, showing a red square at the side where the user forgot to pay attention to (by not pressing the left or right arrow keys). At the end of every lesson student's performance is rated with a score between 0 and 10. Carsten and Jamson (2011) described three levels of simulators: high-level, mid-level and low-level, where high-level simulators are complete cabs with incorporated motion systems and low-level simulators are built around elements such as game controllers and computer monitors. Computers were used to control and operate the first driving simulators, in which the driver sits in a fabricated car chair and performs the driving tasks using a steering wheel, brake pedal and accelerator (Kang, Jalil & Mailah, 2004; Allen et al. 2003). However, there is no previous research of a low-level driving simulation that makes use of computer parts like the mouse and keys to control the simulation.

1.3 Learning processes when learning how to drive

To understand more about the use of driving simulators it is important to examine which learning processes are involved when learning how to drive. Learning how to drive involves motor skill learning that is acquired through perceptual-motor tasks. Driving a car involves incoming perceptual information from the driver's surroundings and response output from the driver at the same time. It also requires a consideration of situations ahead and maneuvering the vehicle properly. These control actions dependent on perceptual processes that select relevant information and compare this information to a standard (Fuller, 2011). At the start of their driving education, students find themselves in the cognitive stage of the model of skill acquisition defined by Fitts and Posner (1967). In this first stage, the actions that are needed for a certain situation are learned step-by-step. A large amount of cognitive activity is necessary since everything is new and a sequence of actions needs to be memorized. The cognitive phase is followed by the associative and autonomous stages where less cognitive activity is needed and actions will become automated. Skills develop as an exponential function of practice (Heathcote, Brown & Mewhort, 2000), this means that the gain of exercises, in practice, is rather slow at the beginning of the learning process but will increase rapidly after a certain amount of practice.

The ACT-R (Adaptive Control of Thought- Rational) theory of Anderson (1993), assumes that human knowledge is divided into two kinds of representations: declarative and procedural representations. In long term memory, there are three types of knowledge assembled in the learning process: declarative knowledge (factual information like traffic rules), procedural knowledge (how to perform an action) and conditional knowledge (knowing when and why to apply certain information) (Woolfolk, Hughes & Walkup, 2013) According to Anderson, working memory is an active buffer between incoming information on one side and declarative memory and procedural memory on the other side. Working memory allows someone to temporarily hold and manipulate incoming information (Mayer, 2014). Facts are stored in long term memory by making associations between parts of the received information and repetition of the information. Motor skills are stored in procedural memory by matching action patterns to each other. In case of driving a car, actions like putting the car in first gear, slowly release the clutch and pressing the accelerator pedal have to be connected to each other, which results in one fluent action. This model has been reviewed and complemented by many researchers. Salvucci (2006) modeled driving behavior in a cognitive architecture using the ACT-R, with the focus on highway driving. The model consists of 3 main parts: the control component (for example steering), the monitoring component (situational awareness) and the decision making component (for example changing lanes). Barkley and Cox (2007) also described driving as a hierarchical model that consists of 3 competencies: operational (basic skills of driving, visual scanning), tactical (behavior and decision making skills, passing other vehicles) and strategic competency (decision and planning skills related to when to drive, weather conditions). These models are comparable with the skills-rules-knowledge framework of Rasmussen (1983) where he describes three levels of human performance. Skill-based behavior characterizes sensory-motor performance without conscious control, which can be viewed as the operational or control component. Monitoring and tactical competencies are examples of rule-based behavior since performance is goal directed and based on stored rules. Lastly, strategic competencies like planning when to drive using prior knowledge is an example of knowledge-based behavior.

To maintain the task-specific knowledge in working memory during the first stage of skill acquisition, verbal mediation is often used. For learning task-specific rules the process of substituting a retrieved fact from declarative memory by a new rule plays an important role (Johnson, 2003). Constant repetition of information during their driving lessons will enable students to store declarative information like traffic rules into their long term memory.

1.4 Driving simulators for practice

Driving simulators are frequently used as research tools and their use in studies about driving performance and behavior has been increasing over the past few years. Two big advantages of using a driving simulator are the possibility to control experimental conditions and to create desired and relevant scenarios (Carsten & Jamson, 2011). Several studies show no difference between driving performance on the simulator and on the road (*headway choice*: Risto & Martens, 2014; *driving errors when negotiating turns*: Shechtman, Classen, Awadzi & Mann, 2009; *hazard detection*: Underwood, Crundall & Chapman, 2011), indicating high reliability of a simulator as a research tool. Reaction time and the choices that were made during an accident in the simulator can be used in crash analyses and can contribute to the development of test scenarios to evaluate someone’s driving behavior (Chrysler, Ahmad & Schwarz, 2015).

In 2010, there were around 150 driving simulators in use by driving schools in the Netherlands, usually mid-level simulators (SWOV-Factsheet, 2010). Driving simulators often replace the first lessons or they are integrated in the complete training in which tasks are trained in the simulator first and performed on the road directly afterwards (Kappé & Van Emmerik, 2005). Fuller (2008) described the main advantages of a driving simulation during training: fast exposition to a wide variety of traffic situations, improved possibilities for feedback, unlimited repetition of educational moments, computerized and objective assessment, demonstration of maneuvered and a safe practice environment.

A disadvantage of a driving simulator is the possibility of motion sickness which occurs when the eyes register movement (on the screen), but the organ of balance registers nothing (the simulator stands still). However, simulator sickness is more frequent among experienced drivers than among persons with very little driving experience (Kappé & Van Emmerik, 2005). A driving simulation could therefore be suitable for people at the start of their driving lessons when experience is low. Other variables that influence simulator sickness strongly are the size of the display, history of motion sickness, session duration and optic flow (Kuipers, 2014). According to Kuipers these multiple variables should be manipulated to reduce the chance of simulator sickness, by for example decreasing the size of the display. A literature review by Pollatsek et al. (2011) showed that the following actions can be trained successfully by novice drivers on a driving simulator: anticipating on specific hazards, scanning more broadly within the general driving environment, prioritizing attention and manoeuvring the vehicle more safely (all without becoming overconfident). Moreover, a comprehensive training intervention consisting of virtual scenarios on a driving simulator, feedback and videos of experienced drivers handling road hazards showed improvement in anticipating, recognizing and dealing with hazards (Wang, Zhang and Salvendy, 2010).

Research group DATA from the Technical University of Delft examined the reliability of driving simulators that were developed and provided by Green Dino. They found that violations and speed in the simulator were predictive for self-reported on-road violations (De Winter, 2013) and they described the predictive power of simulator measurements in terms of speed, errors and number of violations on the result of the driving test on the road (de Winter et al. 2009). The scores provided by a driving simulator could therefore provide a good indication for a driving instructor whether a student is ready for the final driving exam. Students that took simulator lessons had the same number of driving lessons as students who had only driven in a car, which indicates that a driving lesson could be replaced by a lesson on the simulator (De Winter, 2013). According to Kuipers (2014) the erosion of driving skills is one of the main causes of traffic accidents. He proposes a data oriented approach to interface design (DATA Centered Design) to monitor the erosion of skills. Using the scores from the simulator to adjust the frequency of feedback and determine the start of the next task could prevent the erosion of skills.

1.5 Online simulations and virtual reality

There are multiple studies that show the benefit of adding or combining computer simulations to traditional instructions in education (Petzoldt et al., 2013; Rutten, van Joolingen & van der Veen, 2012; Smetana & Bell, 2012). In the field of medicine there are promising results of surgical skill training that combines information on a computer screen with the practice of psychomotor skills using simulated tissue models (Kneebone & Simon, 2001) and the usefulness of virtual reality surgical simulators in which the skills of novices improved as much as they would with conventional training (Torkington, Smith, Rees & Darzi, 2014).

Research in the field of traffic psychology that is focused on online simulations or virtual reality also shows promising results. Pollatsek, Narayanaan, Pradhan and Fisher (2006) showed that a PC-based risk awareness and perception training can successfully help novice drivers to identify where potential risks are located and what information should be attended. Furthermore, Pradhan et al. (2009) found that young drivers who followed a PC based hazard anticipation training increased their scanning behaviour and were more likely to gaze at areas of the roadway with relevant information about potential risks then the untrained drivers. Weiss, Petzoldt, Bannert and Krems (2013) examined the difference in effect of computer-based learning compared to paper-based learning on improving drivers' calibration skills (the ability to balance task demands and capabilities). The computer-based intervention group was given an application that showed traffic scenarios using animated videos whereas the paper-based intervention group was shown static images from those videos. The feedback for the paper-based learners was only a presentation of the correct results and the computer-based learners received response-related, informative feedback about the quality of their performance. The results showed that students who received the computer-based learning material would detect situation-specific hazard cues sooner and show better comprehension of the information. They also developed more defensive self-efficacy expectations and it increased the insecurities of the students which will reduce the chance that the students will overestimate their own driving skills.

1.6 Research question

Most research focuses on high- and mid-level driving simulators, there is little knowledge about the effects of a low-level online driving simulator. Young drivers have the highest risk of accident involvement and gaining more experience might decrease this risk. It is therefore important to examine whether adolescents could gain experience with the help of a low-level online driving simulation. In order to improve their driving style, the actions and movements that are learned with the mouse and keyboard need to be transferred into actions in a real car using a steer and pedals. The main question of this study was: *Is it possible to improve driving skills among adolescents without driving experience using an online driving simulation?*

Since driving simulators are a reliable measurement of driving performance, a mid-level driving simulator was used to evaluate the effectiveness of the low-level driving simulator developed by Green Dino. A control group was used to determine whether improvements were due to the online simulation. The mid-level driving simulator was able to score driving skills on various topics, shown in a safety report (appendix 4). Previous studies showed that experience in taking turns resulted in less accidents among young novice drivers (Clarke et al. 2006), so the lessons that were performed on the online simulation were focused on turning left, turning right and approaching intersections.

2. Methods

2.1 Participants

There were 42 participants in total, equally distributed over two groups, an experimental group and a control group. The complete group of participants consisted of 15 males and 27 females, with an age between 15 and 25 and an average age of 19.79 (SD = 2.031). Educational level varied between the lowest level of secondary school and university level, with mostly university students (73.8%). Inclusion criteria were no (or very little) driving experience and an age between 15 and 25 years. Participants were randomly assigned to either the experimental group or the control group right before they started with the experiment.

Participants were acquired via social media and a sign-up system for students of the behavioural faculty of the University of Twente in the Netherlands. Students from this faculty were able to sign up for the experiment and would retrieve a participation credit in return. Several posters were hung up around the campus of the University of Twente and at one high school in Enschede. Furthermore, every participant was approached to ask their friends to join the experiment. To motivate people to participate either a gift card of 5 euros or a participation credit for students was given to each participant after completing the experiment.

2.2 Measures and Materials

To measure differences in driving behaviour before and after the online driving simulation two mid-level driving simulators were used, one of them is shown in figure 1. These simulators were provided by Green Dino and were placed opposite to each other in one room on the campus of the University of Twente for four weeks. This made it possible to invite two participants at the same time. Green Dino adjusted their driving test for the experiment so that it would take 10 minutes and there would be no verbal instructions during the ride. Data from the driving simulators included a safety report and a strength/weakness report. On every topic a score between 0 and 10 was given, 0 was the lowest possible score with the most mistakes and 10 was the highest possible score with the least mistakes. The scores of the strength/weakness report were based on the number of mistakes in comparison with the number of occurrence of the specific situations, like for example mistakes when turning right. The scores were formed by comparing the performance of the person with the performance of the average student. The score of the average student is based on simulator results of more than 10.000 students who performed all driving lessons on the simulator. If a participant scored higher than 5.5 he or she performed better that the average student and if the score was lower than 5.5 he or she performed worse. The scores on the safety report were absolute scores.

Figure 1. Driving simulator: Drive Master LT, manufactured by Green Dino.

Two computers were placed on a table in the same area as the driving simulators. They were also placed opposite to each other, so the participants could not see each other's screen. Both computers had a mouse attached to it. One laptop was for the experimental condition on which participants performed the following lessons on the laptop of the online module called 'Jonge Automobilisten': taking corners (lesson 15), position on the road in urban areas (lesson 18), turning right (lesson 26), turning left (lesson 27) and approaching crossroads (lesson 28). A virtual instructor was giving verbal feedback about for example appropriate speed and position on the road. A paper with instructions about the use of the mouse and keyboard and the order of lessons was placed next to the laptop for the experimental condition (Appendix 1). These instructions were also given verbally. This setting is displayed in figure 2. The control group played the computer game named "Portal" on the other computer. Portal is a puzzle platform video game where puzzles need to be solved by using portals to transport a character to different areas.

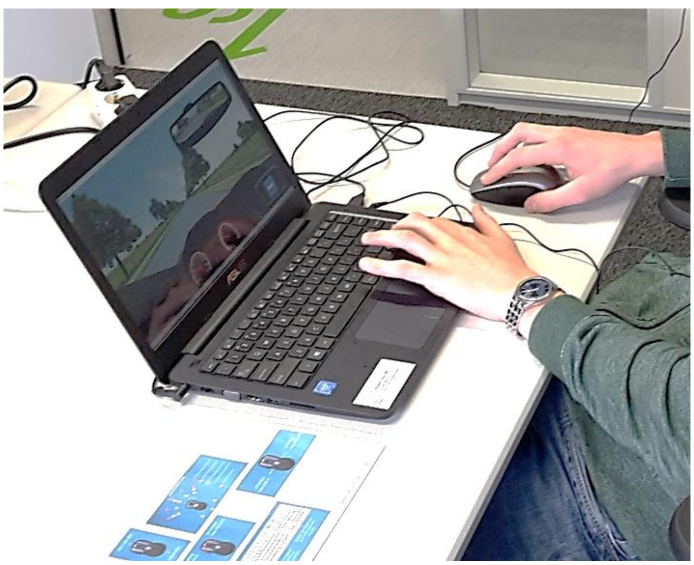

Figure 2. The online driving simulation in the setting of the experiment.

Additional materials were the informed consent form (Appendix 2 and 3) and the questionnaire that consisted of two parts which can be found in Appendix 4. The questionnaire was created to measure if participants estimated their own performance correctly on both the pre- and post-test (and their improvement) using a five point Likert scale with specific aspects of driving skills to increase reliability and validity (Sundström, 2008). The questionnaire consisted of six questions about the following topics: score on the driving test, fluent steering, the position on the road, safe speed taking turns, safe speed in general and approaching intersections. The experimental group received five additional questions about their experiences with the online driving simulation, using a five point Likert scale as well.

2.3 Design and Procedure

To examine the effect of the online driving simulation a randomized controlled trial was conducted with a mixed design; condition (experimental or control group) as between subjects factor and time (difference between pre- and post-test) as within subjects factor. Firstly, participants made an appointment at what date and time they would participate in the experiment. At the start of the experiment they were informed about the content and were given the time to read and sign the informed consent form. There was also a moment for questions in case something was unclear. The procedure that followed is displayed in figure 3.

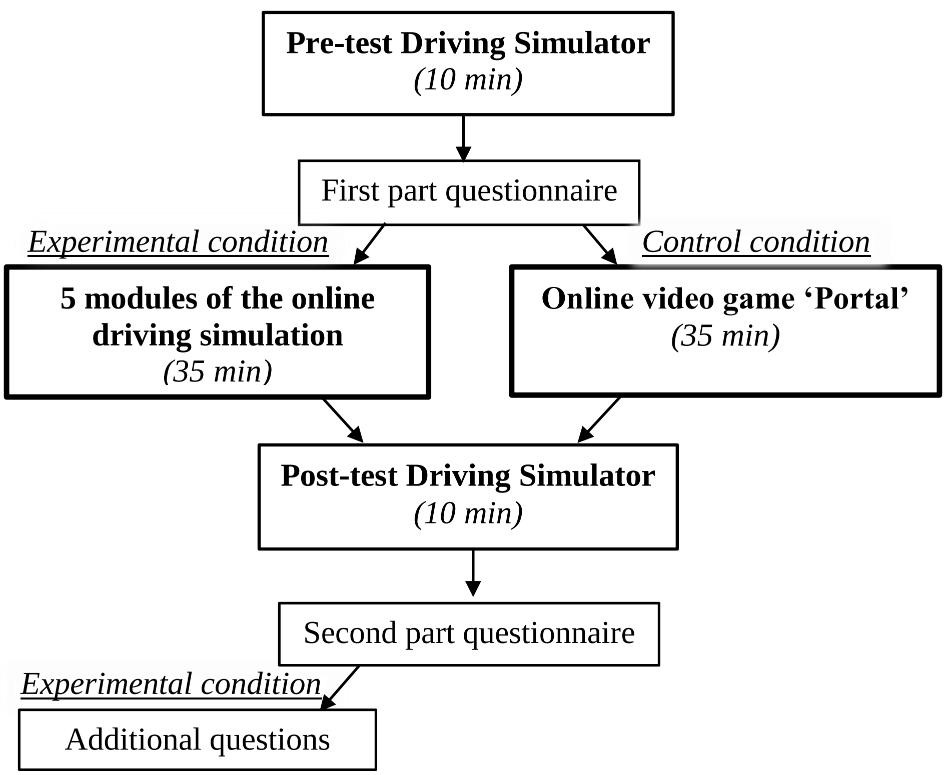

Figure 3. Schematic representation of the procedure of the experiment.

The participants followed the test on the mid-level simulator without any verbal instructions during the drive. Since the participants had no experience in shifting gears and this would add too much cognitive load, the settings of the simulator were set to automatic gear shift. The post-test was the same drive as during the pre-test, with the same settings on the driving simulator. After completing the whole experiment, participants were debriefed and they received the gift card of 5 euros or participant credits. At the end they were asked if they wanted to receive the findings of the research which would be sent to them by email.

2.4 Analysis

From the Strength/Weakness report only the overall Strength/Weakness score was taken into consideration during the analysis, since the amount of relevant situations on every topic varied between all participants, which made it difficult to compare. The safety report consisted of several categories, displayed in table 1, the ten specific scores on the right were included in the analysis. The complete safety report can be found in appendix 5.

Table 1.
Categories of the safety report and the specific scores that were included in the analysis

Overview	➢ Driving skill
	➢ Safety score
Looking behaviour	
Vehicle control	➢ Position inside lane
	➢ Smooth steering
Observation and anticipation	➢ Fluent braking
Maintain safe speed	➢ Safe speed straight roads
	➢ Safe speed approaching intersections
	➢ Safe speed crossing intersections
Fluent driving	➢ Fluent speed approaching intersections
	➢ Fluent speed crossing intersections
Adhere to traffic rules	
Collisions	

First, the data was explored by plotting the different variables in order to make the differences between the conditions visible using a multiple line chart and a simple error bar chart which includes confidence intervals. This was followed by a multivariate mixed design analysis of variance (MANOVA) to determine the effect of the online driving simulation on the participants' driving performance. This analysis was chosen since the two conditions needed to be compared on multiple dependent variables at the same time to form a conclusion about overall driving performance. A two-way mixed ANOVA was performed on the strength/weakness score since it was not possible to include this variable in the MANOVA due to two variables sharing more than

90% with each other. The variable ‘Safe speed taking turns’ was planned to be taken into account since the lessons on the online simulation included turning left and right. However every participant reached a score of 10 on both the pre- and post-test so it was left out of the analysis. Therefore, the different parts of ‘safe speed approaching an intersection’ and ‘safe speed crossing an intersection’ namely ‘turning right’ and ‘turning left’ were analysed as well using a two-way mixed ANOVA. Effect sizes were extracted from the data to determine the magnitude of the effect of the online simulation on the different variables.

Medians of the given answers on the first and second part of the questionnaire were compared between the two groups to determine whether their subjective assessment had changed. In addition, correlations between changes in the subjective estimations and objective changes between the pre- and post-test were studied to investigate whether the experimental group showed more accurate subjective assessment than the control group. Finally, from the extra questions that were only answered by the experimental group, medians were obtained for every question as well as the interquartile ranges (IQR).

3. Results

3.1 Exploratory

Plotting the mean scores of the pre- and post-test for both groups made small differences between the two groups visible as shown in figure 4.

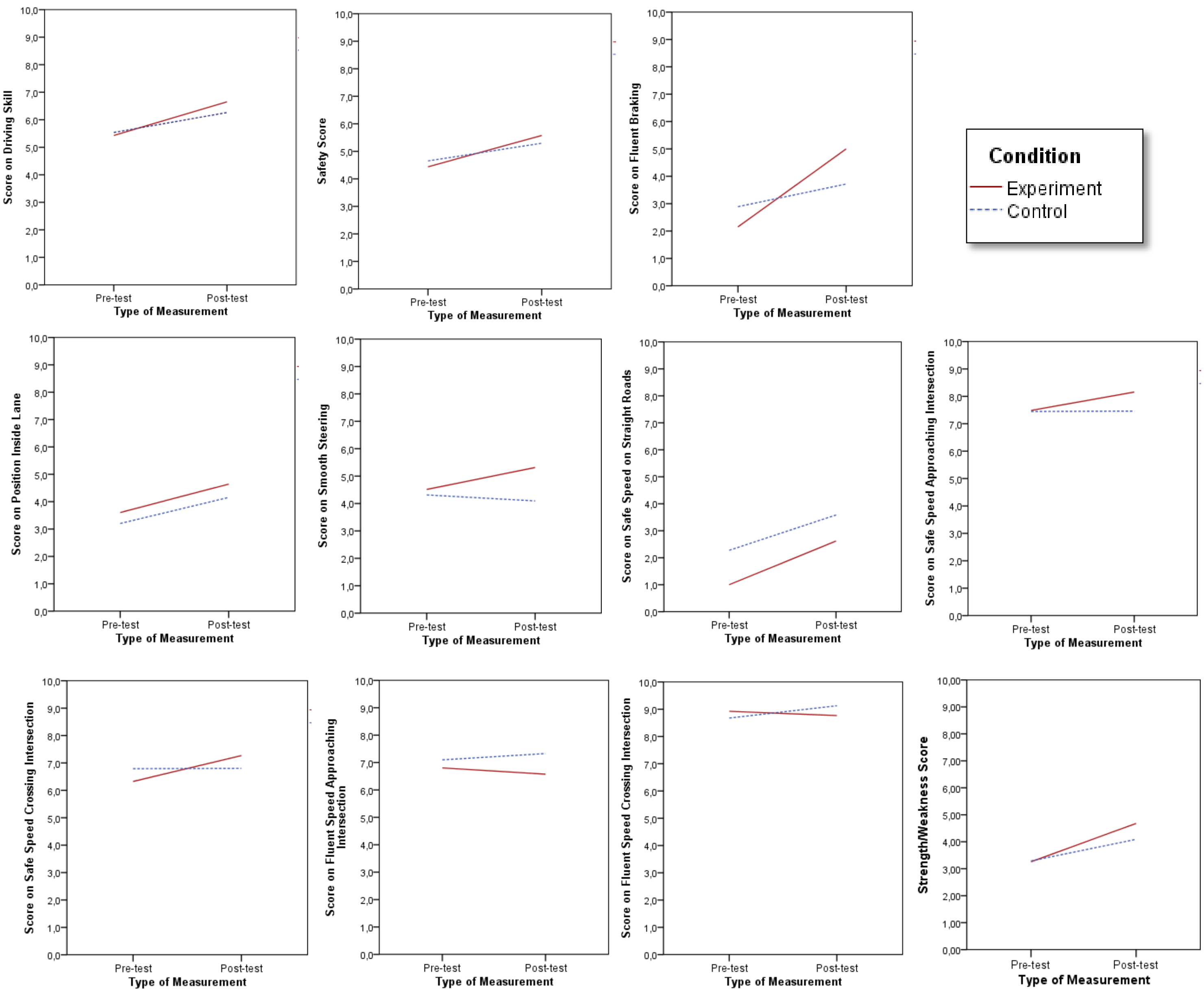

Figure 4. Plots of mean scores of both groups during the pre- and post-test.

3.2 Analysis

3.2.1 Driving performance

A multivariate mixed design analysis of variance (MANOVA) was run to determine the effect of the online driving simulation on the participants' driving performance. From the safety reports derived from the driving simulators ten measurements of driving performance were assessed: 'driving skill', 'safety score', 'position inside lane', 'smooth steering', 'fluent braking', 'safe speed on straight roads', 'safe speed approaching intersection', 'safe speed crossing intersection', 'fluent speed approaching intersection' and 'fluent speed crossing intersection'. Each measurement was conducted two times per participant, as a pre-test and a post-test. There was homogeneity of variance between the two groups, as Box's M test showed no significance (p = .027). Not all assumptions of the MANOVA were met, since a few residuals were not normally distributed. However, a MANOVA is quite robust to violations of normality. There was no interaction effect between time and condition, $F(10, 31) = 1.890$, $p = .085$; Wilks' $\Lambda = .621$; partial $\eta^2 = .379$. The differences between the two groups on the combined dependent variables was not statistically significant, $F(10, 31) = 1.014$, $p = .454$; Wilks' $\Lambda = .753$; partial $\eta^2 = .247$. The differences between the pre- and post-test (time) on the combined dependent variables however was statistically significant, $F(10, 31) = 7.489$, $p = .000$; Wilks' $\Lambda = .293$; partial $\eta^2 = .707$. Analysing the univariate interaction effects including a Bonferroni correction showed there was only a statistically significant interaction effect of time and condition on 'fluent braking', $F(1, 40) = 11.398$, $p = .002$; partial $\eta^2 = .222$. The confidence intervals of 'fluent braking' also did not overlap as shown in figure 5, confirming a significant difference between the two groups.

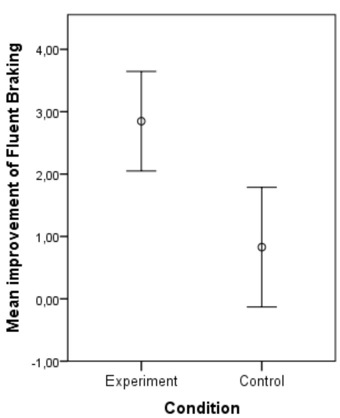

Figure 5. Mean improvement between pre- and post-test of both groups with a 95% confidence interval.

3.2.2. Strength/Weakness Score

It was not possible to use the strength/weakness score in the MANOVA as well, since it shared more than 90% with another variable, which made it not possible to test for equality of covariance. In order to find out whether an interaction between time and group existed a two-way mixed ANOVA was performed. There was homogeneity of variance between the two groups, as Box's M test showed no significance (p = .911). The results showed a significant difference between the pre- and post-test, $F(1, 40) = 30.068$, $p = .000$; Wilks' $\Lambda = .571$; partial $\eta^2 = .429$, but no significant difference between the two groups: $F(1, 40) = .997$, $p = .324$, partial $\eta^2 = .024$. Most importantly, it showed no interaction effect between time and condition, $F(1, 40) = 2.366$, $p = .132$; Wilks' Λ = .944; partial $\eta^2 = .056$.

3.2.3. Taking turns

Since every participant scored a 10 on both the pre- and post-test on 'safe speed taking turns' a two-way mixed ANOVA on 'turning right' and on 'turning left' when approaching and crossing an intersection was performed to test whether practicing on the online simulation had an effect on taking turns. Loss of control on curves were a particular problem for young drivers and gaining experience with taking turns resulted in quick improvement (Clarke et al. 2006). Approaching an intersection turning right showed an interaction effect between time and group $F(1, 31) = 4.976$, p = .033; Wilks' $\Lambda = .869$; partial $\eta^2 = .131$. There was homogeneity of variance between the two groups, as Box's M test showed no significance (p = .009), with the experimental group (n = 18) and the control group (n = 17). For approaching an intersection turning left there was no interaction effect between time and condition, $F(1, 35) = .048$, $p = .828$; Wilks' $\Lambda = .999$; partial $\eta^2 = .001$. There was homogeneity of variance between the two groups, as Box's M test showed no significance (p = .067), with the experimental group (n = 18) and the control group (n = 19).

Crossing an intersection turning right showed no interaction between time and groups, $F(1, 33) = 1.280$, $p = .266$; Wilks' $\Lambda = .963$; partial $\eta^2 = .037$. There was homogeneity of variance between the two groups, as Box's M test showed no significance (p = .365), with the experimental group (n = 18) and the control group (n = 17). Turning left also showed no interaction effect between time and group, $F(1, 38) = 1.078$, $p = .306$; Wilks' $\Lambda = .972$; partial $\eta^2 = .028$. There was homogeneity of variance between the two groups, as Box's M test showed no significance (p = .439), with the experimental group (n = 20) and the control group (n = 20).

3.2.4. Effect sizes

Cohen's (1988) guidelines for Cohen's *d* were followed to examine the magnitude of the difference between the groups when it comes to the improvement on the determined variables (including the disaggregated variables like turning left and right). According to Cohen, a cohen's *d* of .2 shows a small effect, a *d* of .5 indicates a moderate effect and a *d* of .8 or higher should be interpreted as a large effect. Two variables showed a large effect size of the online simulation: fluent braking (*d*=1.04), safe speed approaching intersections-straight on (*d*=.91). Moderate effect sizes were shown by: the strength/weakness score (*d*=.47), driving skill (*d*=.49), safety score (*d*=.49), smooth steering (*d*=.55), safe speed approaching intersections-turning right (*d*=.75), safe speed crossing intersections (*d*=.49), fluent speed crossing intersections (*d*=-.49). Six variables showed a small effect size: safe speed approaching intersections (*d*=.42), safe speed approaching intersections-stopping (*d*=-.28), safe speed crossing intersections-turning right (*d*=.38) safe speed crossing intersections-straight on (*d*=.37), safe speed crossing intersections-turning left (*d*=.33) and fluent speed approaching intersections (*d*=-.32). Lastly, three variables showed an effect size close to zero: position inside lane (*d*=.09), safe speed straight roads (*d*=.13), safe speed approaching intersections-turning left (*d*=-.07).

3.2.5. Self-assessment of driving skills

The questionnaire consisted of 6 statements to inquire information about the self-assessment of participants' driving skills (table 2). The improvement of this subjective self-assessment was compared with the objective improvement that was shown by the data from the driving simulator by checking correlations. The answers to every statement varied between 1 (totally disagree) and 5 (totally agree). Only the first 3 statements could be connected to one of the scores from the driving simulator, the other statements were not directly comparable with the data from the simulator due to ambiguity and missing proper data of taking turns. All statements are displayed in table 1. There was no correlation between subjective improvement (statement 1) and objective improvement (strength/weakness score) on overall performance for either the experimental group (Pearson's $r(21) = .085$, $p = .715$) and the control group (Pearson's $r(21) = .082$, $p = .724$). There was no correlation for smooth steering (statement 2 and 'smooth steering') for the experimental group (Pearson's $r(21) = -.079$, $p = .733$) and the control group (Pearson's $r(21) = -.103$, $p = .658$). Also there was no correlation of position on the road (statement 4 and 'position inside lane') for the experimental group (Pearson's $r(21) = .012$, $p = .958$) and the control group (Pearson's $r(21) = -.325$, $p = .151$).

Table 2.
Medians of answers on the questionnaire on the pre- and post-test.

Statements	Experimental group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
1) "I think I scored well on the test in the simulator"	3.0	4.0	2.0	3.0
2) "steering went in one smooth motion"	3.0	4.0	2.0	4.0
3) "I had a safe speed when taking turns"	2.0	4.0	4.0	4.0
4) "My position on the road was correct"	3.0	3.0	3.0	3.0
5) "I kept the right speed everywhere"	2.0	3.0	3.0	3.0
6) "I know where I should pay attention to when I approach an intersection"	3.0	4.0	3.0	4.0

3.2.6. Questions experimental group about the online driving simulation

A separate questionnaire was used to indicate how much participants agreed with the five statements about the online driving simulation. This part of the questionnaire was only answered by the 21 participants of the experimental group. A five point Likert scale was used with answers varying between 1 (totally disagree) and 5 (totally agree). Table 3 shows the median of the given answers for every question and IQR (interquartile range) with the first and third quartile. A low IQR indicates a low variance between the given answers by the participants.

Table 3.
Answers on the questionnaire of the experimental group

Statements	Median	IQR	First quartile	Third quartile
"Controlling the online simulation was difficult"	4.0	1.0	3.0	4.0
"The online simulation was fun to do"	3.0	1.0	3.0	4.0
"The online simulation was not informative"	2.0	0.0	2.0	2.0
"I would like to do the online simulation more often"	3.0	2.0	2.0	4.0
"I think the online simulation could help me to learn how to drive"	4.0	1.0	3.0	4.0

4. Discussion and Conclusion

4.1. Discussion of the findings

The results show that there was no significant difference between the two groups when the 10 variables were combined. The following paragraphs will discuss the findings of every variable separately and will indicate which skills could possibly be improved by practicing on a low-level simulator and which skills could not.

Driving skill and Safety score were two very general variables. They were both not significant and their effects were moderate after 35 minutes of practice. This study shows no evidence that driving skill and safe driving can be improved by practicing on an online driving simulator. However, a moderate effect indicates that the online simulation had a (small but clear) influence on the improvement of these skills. Since skills develop in an exponential function of practice (Heathcote, Brown & Mewhart, 2000) so driving skills and safe driving will mostly improve after several practice hours. The learning effect of these perceptual motor skills will probably be visible during the associative or autonomous stage of the model of skill acquisition defined by Fitts and Posner (1967) instead of the first cognitive stage.

Practicing with the online driving simulation did not result in a better position on the road in the simulator. Summala, Nieminen and Punto (1996) showed that novice drivers mainly use foveal vision (close to the car) to stay in the lane, but after more practice they managed to keep their position on the road with more peripheral vision. This peripheral vision enables them to anticipate better on their surroundings since they look further ahead than only to the road that is right in front of the car. The possibilities to teach students a more peripheral vision with a low-level simulator are limited with only one computer screen. A mid-level simulator is probably more appropriate since it consist of three screens which creates a larger visual angle. The perspective of the driver as regards to their position in the car and on the road may be different on one computer screen in comparison to multiple or bigger screens. In gaming, a large screen leads to higher physical and self-presence (Hou, Nam, Peng & Lee, 2012), so the bigger screens on the driving simulator might make the driver feel more physically present in a car.

Practicing on the online simulation resulted in a moderate effect size on smooth steering. When it comes to steering a car on a winding road the driver has two tasks: matching the road curvature and keeping a proper distance from the lane edges (Land & Horwood, 1995). Groeger (2000) describes these two tasks in two processes, a long-range process and a short-range process.

The long-range process includes preview of the curvature of the road coming ahead, to predict and anticipate on possible gross steering movements. The second process is a more corrective function allowing the driver to slightly modify the current heading to avoid getting to close to the road edge. The online simulation verbally mentioned when the virtual car was driving too much to the left or to the right side of the lane, in this way the student was enabled to improve this short-range process. The long-range process however, is more difficult to address with a low-level simulator since curvature of the upcoming road and its consequences are difficult to predict behind a computer screen.

The finding that the online simulation had an effect on fluent braking after 35 minutes of practice on the computer is surprising since it indicates a transfer between moving the mouse up and down and using the brakes in the simulator. These movements show some resemblance since they are in the same direction, pushing forward and pulling back. However, it is counterintuitive to pull the mouse to stop the car since pushing the brake pedal in the car causes the car to stop. Seibt, Neumann, Nussinson and Strack (2008) showed that the direction of the movement does not determine whether it should be interpreted as approach or avoidance, but rather the relation of the motion to either the self or the object as a reference point. Pressing the brake pedal away from the self is avoiding that the car will go too fast, therefore the self is taken as a reference point. Using the brakes in the online driving simulator includes moving the mouse away from the screen, indicating avoiding behaviour with the object as a reference point. This difference in reference point may be an important difference between a mid-level driving simulator and the online driving simulation. Several factors influence braking performance: current speed, the point at which the driver decides to start braking, the severity of braking of which the vehicle is capable, and the severity of braking and extent of braking adjustment the driver can tolerate, the friction that can be achieved between the surface of the road and tyres, and the margin of error relative to the ultimate distance to the target (Groeger, 2000). A low-level simulator could improve the point at which the driver decides to start braking, by indicating verbally or visually when this moment arrives. The friction between the road and tyres, capability of the car and the capability of the driver could only be experienced in a real car when the force of the deceleration is tangible.

Regarding a safe speed during driving, Fuller (2005) created a task-capability interface (TCI) model in which he describes the concept of task difficulty. According to him, task difficulty is produced by the interaction between task demands and driver capability. In order to keep task difficulty within boundaries Fuller proposes speed choice as the solution to find balance between task demands and driver capability. In order to be able to cope with a task that is perceived as difficult, adjusting the speed is mainly the first and best reaction. Adjusting the speed gives the driver more time to make decisions and anticipate on his or her surroundings. This is teachable with the online driving simulation since the virtual instructor reminds the student to adjust their speed right before every intersection. However, the results showed no significance and only a small effect for safe speed. The reason for this is that all participants already scored relatively high on the pre-test so it is logical that participants did not improve on the post-test and that there was no significant difference between the two groups. The same counts for 'fluent speed crossing intersections' and 'fluent speed approaching intersections'.

Safe speed 'straight on' and 'turning right' when approaching an intersection showed a large and moderate effect size, with the improvement of the experimental group being bigger than the improvement of the control group. The effect size of 'turning left' was close to zero. Safely turning right might possibly be easier to improve than turning left. One explanation could be that turning right includes less difficult tasks that turning left since the street does not have to be crossed and the focus is solely on vehicles coming from the left. Due to opposing traffic, turning left gives more cognitive workload than turning right (Hancock, Wulf, Thom & Fassnacht, 1990). When turning left, drivers have to think more about giving priority to other vehicles, which is difficult for inexperienced drivers without full knowledge of all the traffic rules. However, this distinction was not shown when crossing an intersection; 'turning right', 'turning left' and 'straight on' all showed the same (small) effect. When approaching an intersection tactical competencies like decision making from the model of Barkley and Cox (2007) or rule-based behavior from the framework of Rasmussen (1988) are necessary. This is followed by crossing the street, which involves more skill-based behavior and operational competencies like controlling the vehicle that could not be improved by the online driving simulation. The online simulation is therefore more suitable for training how to approach an intersection than for crossing an intersection.

Paräaho Keskinen, and Hatakka (2003) emphasized that self-evaluation, self-assessment and self-awareness are just as important as knowledge, skills and risk increasing factors in order to be a safe driver. However the present study showed no correlation between subjective and objective improvement and also no difference between the groups. Tronsmoen (2008) discovered that the best self-assessments of their driving ability came from males, experienced drivers, drivers with a high amount of informal training and drivers with the lowest levels of accident risk. Lack of experience might therefore also be an explanation for self-assessments that do not correspond with actual driving ability. Molina et al. (2013) stated that overconfidence is one of the main explanatory factor behind young drivers' accident involvement. After every lesson, the online simulation provides the student with a score, this could potentially prevent overconfidence among young novice drivers.

4.2. Adjustments to the study and the interface

The results of this study showed that improving the skills that were measured was not possible by using the low-level driving simulator. This could indicate ineffectiveness of the online simulation in general or just in the setting of this experiment. Adjusting the study will provide an answer to this question. In previous research, lack of experience was found to be a main cause of traffic accidents among young novice drivers (McKnight & McKnight, 2003; Petzoldt, Weiß, Franke, Krems & Bannert, 2013; Vlakveld, 2005). The participants performed the online simulation for only 35 minutes, so the amount of gaining experience might be too low. In the beginning they had to get used to controlling the mouse and the keys, so the total time spent on the computer has been very short to gain sufficient practice. Nonetheless, this study already showed six positive moderate effect sizes after only 35 minutes of practice. It is therefore possible that the effects will be larger when students make more hours in total on the online simulation. Regarding the interface, every lessons lasted five minutes and loading the next lessons took quite some time. To automate the actions on the simulation, driving lessons should last longer with an increase of difficulty during the drive using for example the data driven design approach (Kuipers, 2014).

Due to technical problems it was not possible to collect data about change in looking behaviour of the participants. Pradhan et al. (2009) already showed that young drivers who followed a PC based hazard anticipation training increased their scanning behaviour. Research done by Green Dino among 2439 former driving students showed that students who followed (mid-level) simulator lessons with registration of looking behaviour were less often involved in traffic accidents than students who followed the lessons without this registration (Rij-instructie, 2016). Also, several Dutch driving schools indicate that errors in viewing behaviour are one of the most common mistakes during the driving exam (Rijbewijs Nederland, n.d.). Studying the effects of the online simulation in looking behaviour should therefore be included in the experiment as well. This can be added by activating a webcam that can be placed on the mid-level driving simulator which analyses the head movements of the driver. These scores will be shown on the safety report. The online simulation is aiming to improve the view behaviour of the student as well since the key arrows are used for looking behaviour and a red square appears on the screen at the side were the student forgot to look. Using the key arrows might have interfered with the movements of the mouse, participants indicated that controlling the simulation was rather difficult. A follow-up study could investigate whether the online simulation is more effective with or without the key arrows and if the key arrows should be introduced after the student has practiced several times with controlling the virtual car using the mouse.

The study of Philip et al. (2005) showed a clear association between sleepiness and degradation in driving performance. Fatigue or a decrease in motivation might have influenced the driving performance of the participants during the experiment since they were sitting behind a screen for a whole hour. Dividing the practice times and the measurement times on the online simulation over one or two weeks would avoid this influence. For example, measuring driving performance on the driving simulator at the start of the week and at the end, with 5 practice moments on the online simulation in between.

The motivation of the participants also decreased during the drive, some participants mentioned that the drive was rather easy. Element interactivity (integration of multiple elements of information) must be high in order to be able to observe learning effects (Sweller, Ayres & Kalyuga, 2011). Differences in driving behaviour might therefore be more visible with more difficult situations that combine multiple elements like high speed and more surprising situations. The reason that all participants scored the highest score on taking turns might be that the turns were too easy, so including more difficult turns or more changes in speed could make the effectiveness of the online simulation more visible.

As regards to the questionnaire, there was no clear improvement in self-awareness since there was no correlation between subjective improvements according to the questionnaire and the objective improvements showed in the data from the driving simulator. However only 3 out of the 6 questions turned out to be really comparable with the objective data. In future research, the questions need to be more comparable with the results of the driving simulator so more variables can be compared with each other. More specific questions about for example fluent braking or turning right that are directly visible on the safety report are required to avoid ambiguity. However the questionnaire for the experimental group showed that controlling the simulation was found to be difficult, but informative. In order to investigate which parts of the simulation are most difficult of unclear a usability study is needed to observe how students handle several tasks with the interface. Several participants commented that the feedback about the use of the mirrors was unclear. They were told that they were doing it wrong, but without instructions on how to improve it. More specific feedback of the virtual instructor is needed to enable the student to improve their looking behaviour.

Finally, the focus of the experiment could be more on declarative knowledge instead of procedural knowledge, considering the previous discussion of the several variables. As the study of Weiss et al. (2013) already showed, computer-based learning could results in better comprehension of the learning material in comparison with paper-based learning. To investigate the difference between learning the traffic rules statically from a book and from a simulation, one group could follow lessons on the driving simulator that involve traffic rules and the control group could learn the same traffic rules by studying a book. In the end both groups should perform a written test about the material to compare the results.

4.3. Conclusion

The current study investigated the effectiveness of a low-level driving simulator. The results indicate that there was no significant difference in improvement of overall driving skills between the experimental and control group when all the variables were combined. However, the driving skills that could potentially be influenced by the online simulation are the short-range process of smooth steering, the starting point of braking and adjusting the speed when approaching an intersection. There was no correlation between the subjective improvement and objective improvement of the participants. Controlling the online simulation was rather difficult according to most participants of the experimental condition. However, most participants found the lessons informative and estimated that it could help them in their process of learning how to drive.

This study contributes to the research field since existing literature focusses mostly on high- and mid-level simulators (Carsten & Jamson, 2011). There is less knowledge about the effect of an online (low-level) simulation on improving driving behaviour with the use of a mouse and keys on the keyboard to control a simulation. Attention is needed since an online driving simulation would be an easy way to offer students more driving experience which could be performed at home and could possibly decrease traffic accidents in the long term. Moreover, many studies that involve driving simulators are focussed on hazard detection by tracking eye-movements (Underwood, Crundall & Chapman, 2011; Wang, Zhang and Salvendy, 2010); improving driving skills like smooth steering and fluent braking received less attention. Although this study did not show significant effects on improving perceptual motor skills, an online driving stimulation could still be effective for other skills. Learning traffic rules for example, which requires declarative- or conditional knowledge could be very well supported by a simulation. Repetition of information and showing visual examples of traffic situations will result in the storage of the information into long term memory. An online driving simulation is therefore very suitable at the start of the driving education to gain declarative knowledge. Further research is needed to determine the effectiveness of the online simulation on perceptual motor skills in later stages of the learning process.

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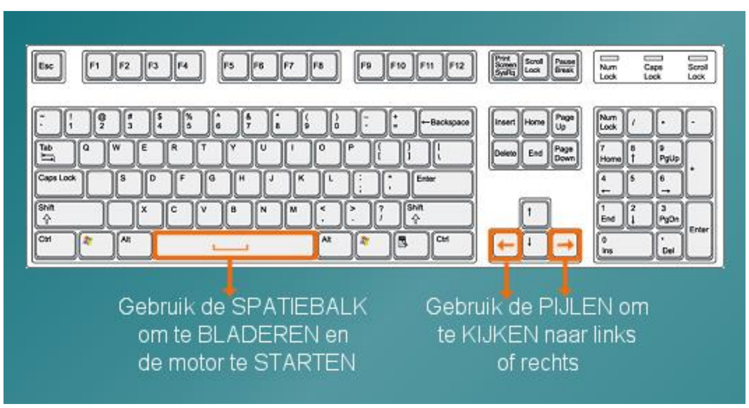
Appendix

1. Instruction paper experimental group



Les 15, 18, 26, 27, 28

2. Informed Consent

Toestemmingsverklaringformulier

Onderzoek: Effectiviteit van een rijsimulatie

Verantwoordelijke onderzoeker: Moniek Scholten

In te vullen door de deelnemer

Ik verklaar op een voor mij duidelijke wijze te zijn ingelicht over de aard, methode, doel en de risico's en belasting van het onderzoek. Ik weet dat de gegevens en resultaten van het onderzoek alleen anoniem en vertrouwelijk aan derden bekend gemaakt zullen worden. Mijn vragen zijn naar tevredenheid beantwoord.

Ik stem geheel vrijwillig in met deelname aan dit onderzoek. Ik behoud me daarbij het recht voor om op elk moment zonder opgaaf van redenen mijn deelname aan dit onderzoek te beëindigen.

Als ik nog verdere informatie over het onderzoek zou willen krijgen, nu of in de toekomst, kan ik me wenden tot Moniek Scholten (m.scholten-4@student.utwente.nl).

Naam deelnemer: …………………………………………………

Datum: …………

Handtekening: ....

In te vullen door de uitvoerende onderzoeker

Ik heb een mondelinge en schriftelijke toelichting gegeven op het onderzoek. Ik zal resterende vragen over het onderzoek naar vermogen beantwoorden. De deelnemer zal van een eventuele voortijdige beëindiging van deelname aan dit onderzoek geen nadelige gevolgen ondervinden.

Naam onderzoeker: ....

Datum: ....

Handtekening onderzoeker: ....

3. Informed Consent when participants are younger than 18 years old

<u>Toestemmingsverklaringsformulier ouders</u>

Titel onderzoek: Effectiviteit van rijsimulatoren
Onderzoeker: Moniek Scholten

Ik verklaar hierbij op voor mij duidelijke wijze te zijn ingelicht over de aard en methode van het onderzoek. Mijn vragen zijn naar tevredenheid beantwoord.

Ik verklaar bevoegd te zijn om voor deelname van het kind aan het bedoelde onderzoek te tekenen. Ik stem geheel vrijwillig in met deelname van het onder mijn gezag vallende kind aan dit onderzoek. Ik behoud daarbij het recht deze instemming weer in te trekken zonder dat ik daarvoor een reden hoef op te geven en besef dat het kind op elk moment mag stoppen met het experiment.

Indien de onderzoeksresultaten van het onder mijn gezag vallende kind gebruikt zullen worden in wetenschappelijke publicaties, dan wel op een andere manier openbaar worden gemaakt, zal dit volledig geanonimiseerd gebeuren. De persoonsgegevens van het kind zullen niet door derden worden ingezien zonder mijn uitdrukkelijke toestemming.

Als ik nog verdere informatie over het onderzoek zou willen krijgen, nu of in de toekomst, kan ik me wenden tot Moniek Scholten (tel: 06-57220841)of e-mail m.scholten-4@student.utwente.nl

Aldus in tweevoud getekend
op 2016

....
Naam proefpersoon

Handtekening:

....
Naam gezaghebbende

Handtekening:

4. Questionnaire

Algemene vragen

Leeftijd: ....
Geslacht: Man/Vrouw
Brommerrijbewijs: Ja/Nee
Opleidingsniveau:

- VMBO
- HAVO
- VWO
- MBO
- HBO
- WO (universiteit)
- Anders, namelijk........................

Vragenlijst 1

Geef bij de volgende stellingen aan in hoeverre je het eens bent met de stelling, door een kruisje in het juiste vakje te zetten.

	Helemaal mee oneens	**Oneens**	**Neutraal**	**Eens**	**Helemaal mee eens**
1) Ik denk dat ik goed heb gescoord op de test in de simulator					
2) Het sturen ging in een vloeiende beweging					
3) Ik had een veilige snelheid tijdens het nemen van bochten					
4) Mijn positie op de weg was juist					
5) Ik hield overal de juiste snelheid aan					
6) Ik weet waar ik op moet letten als ik een kruispunt nader					

Vragenlijst 2

Geef bij de volgende stellingen aan in hoeverre je het eens bent met de stelling, door een kruisje in het juiste vakje te zetten.

	Helemaal mee oneens	**Oneens**	**Neutraal**	**Eens**	**Helemaal mee eens**
7) Ik denk dat ik goed heb gescoord op de test in de simulator					
8) Het sturen ging in een vloeiende beweging					
9) Ik had een veilige snelheid tijdens het nemen van bochten					
10) Mijn positie op de weg was juist					
11) Ik hield overal de juiste snelheid aan					
12) Ik weet waar ik op moet letten als ik een kruispunt nader					

Eventuele opmerkingen:
....
....
....
....
....
....

Extra vragen experimentele groep

	Helemaal mee oneens	**Oneens**	**Neutraal**	**Eens**	**Helemaal mee eens**
13) De besturing van de online simulatie was moeilijk					
14) De online simulatie was leuk om te doen					
15) De online simulatie was niet leerzaam					
16) Ik zou de online simulatie vaker willen doen					
17) Ik denk dat de online simulatie mij kan helpen om te leren autorijden					

Eventuele opmerkingen:
....
....
....
....
....
....

5. Safety Report

Naam	Datum
Rijstijl	<u>Goed</u>
Overzicht	
Rijvaardigheid	Score
Veiligheidsscore	Score
Vermijden van veiligheidsrisico's	Score
Zuinig rijden	Score
Kijkgedrag	
Kijkgedrag	Score
• Voor het links afslaan	Score
• Voor het rechts afslaan	Score
• Voor het rechtdoor gaan	Score
• Voor een rotonde	Score
• Voor het remmen	Score
• Voor het wisselen van rijstrook	Score
• Scannen	Score
Voertuigbeheersing	
Gebruik lichten	Score
Versnelling overslaan	Score
Positie op de weg	Score
Vloeiend sturen	Score
Te hoge toeren	Score
Te lage toeren	Score
Te vroeg schakelen	Score
Voet op de koppeling houden	Score
Te veel remdruk (aantal)	Score
Afslaan motor (aantal)	Score
Observatie en anticipatie	
Inhalen met tegemoetkomend verkeer	Score
Afstand houden	Score
Reactie op tijd	Score
Vlot remmen	Score
Houden aan veilige snelheid	
Op rechte wegen	Score
Snelheid in bochten	Score
Naderen van de kruising	Score
• Om te stoppen	Score
• Om rechtsaf te slaan	Score
• Om rechtdoor te gaan	Score
• Om linksaf te slaan	Score
Oversteken van de kruising	Score

• Om rechtsaf te slaan	Score
• Om rechtdoor te gaan	Score
• Om linksaf te slaan	Score
Op een rotonde	Score
Vlot rijden	
Op rechte wegen	Score
Naderen van de kruising	Score
Oversteken van de kruising	Score
Op een rotonde	Score
Houden aan verkeersregels	
Stoppen voor verkeerslichten	Score
Gebruik van de richtingaanwijzer op kruising	Score
Gebruik van richtingaanwijzer op rotonde	Score
Geven van voorrang	Score
• Op een voorrangskruising	Score
• Op een kruising met verkeerslichten	Score
• Op een gelijkwaardige kruising	Score
• Op een rotonde	Score
Ongelukken (aantal	
Aanrijding met ander verkeer	Score
Eenzijdige aanrijding	Score
Geheel van de weg geraakt	Score
Gedeeltelijk van de weg geraakt	Score