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Testing the effect of a training method on performance in an online driving simulator: replication of the speed episode effect and retention

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Table of Contents

Abstract

Driver training in the Netherlands is often limited to driving in a car. Driving simulators provide a great solution in being able to practice more skills, which cannot be taught in a car for a variety of reasons, such as rare weather conditions. The aim of this study was to investigate performance after a driver training method in an online driving simulator using the so-called speed episode (Weimer, 2019). The speed episode is a block of trials placed in between blocks of trials focused on accuracy, where participants focus on finishing the task as soon as possible rather than error-free. The goal was to discover whether the speed episode effect was also observable in a driving simulator and to investigate if the skills learned in a simulator could be retained for a week. Participants drove two sessions in the online simulator provided by Green Dino. Session 1 contained three blocks consisting of 8 trials, where the second block was the speed episode. Session 2 took place 5-7 days after the first one and consisted of 10 trials aimed at testing retention. From the findings it could be concluded that the manipulation of speed worked, but a speed episode effect in later blocks could not be observed. In both conditions participants were able to retain more than 95% of their skills, and in case of crashes participants were able to improve upon their skills.

1. Introduction

Driving a car is a skill common to a lot of people in wealthy countries. In the Netherlands, two thirds of those applying for a driver's license are under the age of 21, meaning that it is a skill learned at a quite early age (CBS, 2017). However, skills can also be forgotten, meaning that after not using them for a while, a person will get poorer at that skill. An example of a group of people where that can happen is those who work or live at a location where driving a car is not possible or not the most logical transportation option. Think for example of big metropolitan cities such as New York City or London, where taking the subway is a common means of transportation. A great solution for learning or regaining driving skills could be training in a driving simulator. In such a situation, simulators serve as a safe learning environment where there is no risk of an accident.

The current study will focus on the effect of a particular training method on performance in a driving simulator. Unfortunately, not much research exists on this type of application while it has a lot of potential. If driving simulators can be used to teach these driving skills, they could be applied in a number of different settings. An example of such a setting is in driving schools or for training on driving a car in a foreign country, such as the UK where driving happens on the opposite side of the road. There is already some evidence that behaviour shown in a driving simulator is representative of driving behaviour outside of the simulator (Delft Automated Training & Assessment, 2013). Unfortunately, not much research exists on the effectiveness of driver training in a driving simulator and driving simulators are not commonly used in driving schools. A company that is at the forefront of providing driving simulators is Green Dino who produces car, truck, bus, scooter and emergency vehicle simulators (Green Dino BV, n.d.). The technology exists, now the applicability should be tested in sufficient detail. Here, this will be done via a training method that manipulates the speed-accuracy trade-off (SAT) by forcing participants to focus on speed rather than accuracy. This type of manipulation is referred to as a speed episode. This speed episode should result in a speed episode effect, where in the trials after the speed episode a decrease in ToT should be observable (Weimer, 2019). This will be further explained below.

This study will first provide a background on current practice in driver training and the use of simulators. Then an explanation will be provided on the SAT and the effects of its manipulation. Additionally, a look is also taken at the role that retention plays. It might well be that the driving simulator can be used to teach driving skills, but if these skills cannot be retained then its addition to driver training is not effective. Based on the literature discussed in these sections, a research question is posed with associated hypotheses that are then tested in a simulator experiment.

1.1 Background

1.1.1. Driver training in simulators

Currently, driver training entails that people without any experience directly get in a car and start learning how to drive in a high-risk environment. This can cause stress and discomfort for unexperienced drivers because it is an environment where something can easily go wrong which possibly leads to a (fatal) accident. Another disadvantage of the current driver training is that students are limited in what they learn by their environment and the circumstances. If it, for example, does not snow during your driver training, you might get into serious trouble adjusting your driving style to snowy conditions when you received your driver's license. Another example of such a situation is driving when it is not busy on the road, so outside of rush hours. If you are required to enter the highway when it is really busy this requires different skills regarding spatial perception and managing stress than at nine o'clock on a Sunday morning. Driving simulators potentially provide a solution to overcoming some of these disadvantages. This study will further investigate its potential to teach a number of motor skills, such as steering, before the student actually drives on the road. In order for driving simulators to be used for such a purpose, we take a look is at what is known about this and their advantages.

Driving simulators are not widely used for driver training in the Netherlands. In 2010 only about a 100 simulators were used for basic training (Kuiper, 2010). There are a number of driving schools that do so, and a study found that there is a higher chance of passing the driver's exam if someone has trained in a simulator (de Winter et al., 2009). During a simulator training, learners get lessons on several topics, such as vehicle control, and each lesson is concluded with a test. During such a lesson there is guidance from a virtual instructor with instructions and feedback (SWOV, 2010). Also, changes can be made in task difficulty and this can also be adjusted in the form of adaptive changes based on the individual's performance in the simulator. Additionally, there is some evidence that the driving behaviour shown in the driving simulator is representative of driving behaviour a few years after obtaining a license (Delft Automated Training & Assessment, 2013). This means that a transfer of training has been observed from simulator training to the real world (Adams, 1987). If someone would display the behaviour of going over the speed limit in the simulator, he or she self-reported to also show this behaviour after attaining a driver's license. So, there is some tentative evidence that driving simulators are beneficial for driver training. Other benefits of driving simulators that have been discussed include the capacity to expose the trainee to a lot of different scenarios that can occur in traffic, providing a safe environment to practice, and the ability to provide demonstrations of how driving actions should be performed (SWOV, 2019). A driving instructor could for example teach about car handling on slippery roads, which is not something that is included in the regular curriculum. Another advantage of an online driving simulator is that it is a very accessible and inexpensive training set-up. Users would only need a PC that is capable of running the simulator and a mouse, which also means that using the simulator is uncomplicated and accessible to many people.

1.1.2. Manipulation of the speed-accuracy trade-off

Performance, which involves both handling speed and accuracy, works as a trade-off. The speed-accuracy trade-off (SAT) entails that when someone is performing a task it is difficult to achieve the best of both worlds (Wickelgren, 1977). It is the decision made by an individual to go slower and make less errors, or to go faster and make more errors (Zimmerman, 2011). The decision as to what strategy works best is made based on sensory input, constraints imposed by the environment, internal goals and biases, etc. (Heitz, 2014). At the start of training, the SAT can be observed as a long time spent on completing a task which can be accompanied by errors, but not necessarily. Over time and as training continues, individuals will become more skilled at a task and this will lead them to be able to complete a task faster and without errors.

An interesting aspect of the SAT is to investigate the effect of its manipulation, more specifically, its effect on (driver) training methods. If an individual's performance on the SAT can be influenced, this might be a useful method to make learners reach the optimal balance between speed and accuracy faster. Optimal refers to optimal efficiency, which can be achieved using efficient training methods that support individuals in reaching this balance. To our knowledge, this has not yet been investigated for driver training or driving simulators, but it has been in another domain. Gas, Buckarma, Cook, Farley, and Pusic (2018) investigated the effects of time pressure on a simulated blood vessel ligation. They found that both novices and experts all showed a decrease in time after the instruction was given to go 20% faster than their last trial. But, they did not further investigate the effect of time pressure. Another study with a Minimally Invasive Surgery (MIS) simulator went a step further and investigated the effect of a so-called *speed episode* on learning and how it would influence the learning curves of individuals (Weimer, 2019). A speed episode is a block of trials where participants are instructed to go 20% faster than their last trial, meaning the focus shifts from accuracy to speed. This block is put between two other blocks where the focus lies on accuracy. The most important aspect of training is to stop making errors while maintaining a reasonable speed, therefore it is essential that there are accuracy blocks in which learners can focus on learning how a task must be performed correctly. If there were only speed blocks, learners would never learn the correct procedure so their error level would probably stay consistent. A speed episode effect was observed, which entailed that the time on task (ToT) was significantly shorter compared to participants that only focused on accuracy (Weimer, 2019). So, the speed episode effect leads to a "step-up" in ToT. Participants were verbally instructed to go faster. According to Heitz (2014), the advantage using verbal manipulations is that it is a simple change that can induce a big effect. The danger of using verbal instructions is that participants adhere to it strictly at the beginning of a block of trials, but over the course of the block they become less strict. This results in a mean ToT that can vary greatly per participant, stressing the importance of individual level analyses.

The speed episode effect is an interesting finding in light of effective training methods. Usually, speed will only increase at the very end of training, when students make almost no errors. The speed episode is a method for learners to reach the optimal balance between speed and accuracy faster, rather than at the end of training. The present research focuses on the possibility of a domain transfer of the speed episode effect into the domain of driving simulators.

1.1.3. Retention

When investigating whether driving skills can be learned in a driving simulator, its influence on retention is also considered. Do the learned skills last to the next session or do they deteriorate? Although it has been proven that the speed episode is beneficial for training, it has not yet been tested whether it also influences retention. Firstly, it is important to state that retention is not a simple process. How well skills can be retained can be influenced by many factors, such as the degree of similarity between the simulator environment and the real world scenario, the time between training and real world execution, etc. (O'Hara, 1990). It was also found that more engaging learning environments, such as a game, resulted in improved retention of skills (Lohse, Boyd, & Hodges, 2016). Simulators seem to have a big advantage because they can be made realistic and engaging, thus stimulating the retention of skills learned in them.

Another factor that has a big influence on retention is the type of knowledge that is stored in memory. Declarative knowledge is knowledge about information that can be expressed in words, such as facts or traffic rules. Whereas procedural knowledge is about how to do things, such as driving a car, which is expressed in terms of behaviour (Gleitman, Gross, & Reisberg, 2010). Learning is assumed to include three phases. Firstly, declarative knowledge is gathered by the learner on the task that needs to be accomplished, such as the rules on right of way at crossings. In the second phase this knowledge is consolidated, which leads to a combination of declarative and procedural knowledge. In this phase the knowledge on right of way is combined with actions that need to be taken while driving, such as determining what kind of crossing the driver is approaching. In the third phase the knowledge is tuned, meaning that knowing how to apply the learned knowledge is sped up (Kim & Ritter, 2015). This means that the driver does not need to put a lot of effort and thinking into the complete procedure, but rather quickly determines what actions need to be taken based on the crossing that the driver is approaching. Over the course of these phases the time taken to

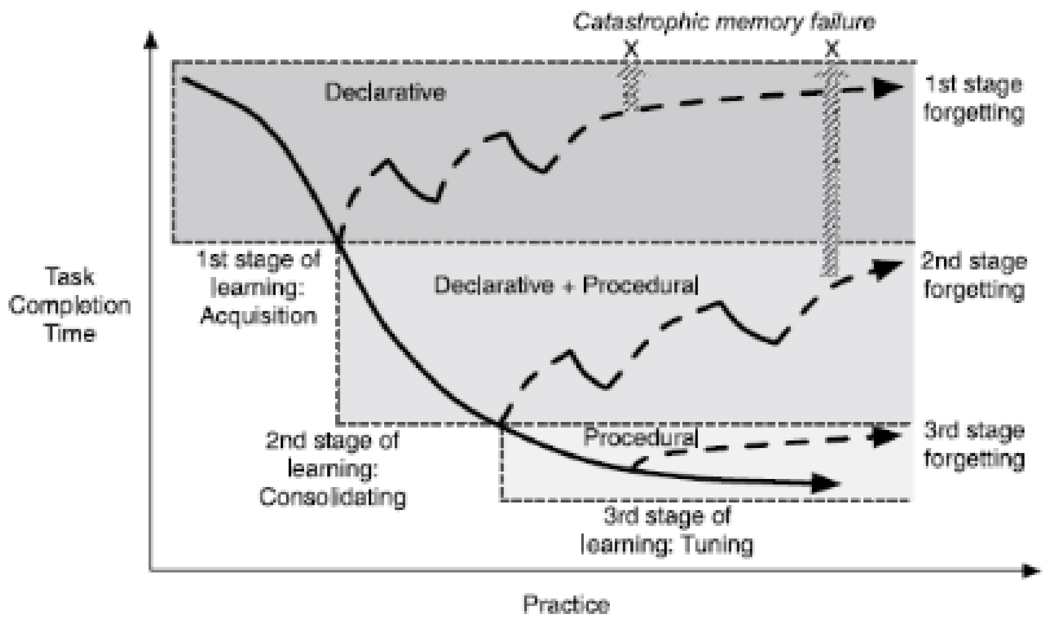

Figure 1. Knowledge retention based on the three learning phases and the effects of forgetting and relearning. Solid lines represent learning and relearning curves. Dashed lines represent forgetting curves (Kim & Ritter, 2015).

perform the task quickly decreases. According to Heathcote, Brown, and Mewhort (2000) this speeding up follows an exponential function. Figure 1 displays the retention of these skills based on the three learning phases. The first and second phase imply that learned knowledge is easily forgotten, up until the point that there is a catastrophic memory failure. This refers to the point in time when a person is not able to perform the learned task anymore. It can also be observed that procedural knowledge is maintained for the most part and that it does not lead to catastrophic memory failure. Driving is a procedural skill. This means that the majority of the skills learned in a driving simulator should be able to be retained.

A look is taken at other studies on retention and simulators. According to some existing research on retention, directly after training, learned skills are rapidly forgotten, and then the level of retention slowly decays over time. So, this is representative of an exponential function. This initial decay phase lasts up until a couple of days and roughly 20-30% of skills is retained in memory (Smith & Kosslyn, 2007; Stahl et al., 2010). Spruit and colleagues (2015) also looked at retention, but for laparoscopic surgery tasks. After a 2-week retention period, half of the tasks had a slight increase in completion times or had a bigger decrease in completion times. As for accuracy scores, most of them stayed the same or slightly increased. This is further confirmed by other research with simulators. In an orthopaedic procedure simulator, it was found that the learned skill/procedure showed no decay a month after the initial training period (Moktar et al., 2016). Another study also did not find any decay of skill level 4 months after the final test for surgical skills (Mitchell et al., 2011). In another simulator, for laparoscopic surgery, it was found that performance deteriorated with 10% 5 months after the simulator session (Stefanidis, Acker, & Heniford, 2008). Similar percentages were also found for other tasks, such as intubation (Ramirez, Hu, Kim, & Rasmussen, 2018). This could also be found in skill training outside of a simulator but with an ultrasound device used by novices (Rappaport et al., 2019). Thus, the medical field provides evidence that there is no retention loss at all up until around a 10 percent loss. However, the retention intervals did differ a lot and it has to be taken into account that skill difficulty likely varied a lot. There is limited research on this topic in domains outside of the medical field. Yesavage and colleagues (2002) found that there was about a 20% retention loss in a flight simulator after 30 days.

Based on the literature on retention in simulators, there are no harsh boundaries for when skills perceptual-motor skills are and are not retained. This seems to be dependent on the task and training. The expectation is that driving skills, which are largely procedural once sufficiently practiced, are retained into a next session.

1.2 Research question and hypotheses

Based on the considerations discussed above, two research questions were posed. What is the effect of speed episode training on performance in a driving simulator? We expect that in order to establish a speed episode, a SAT must be observed. This means that it is expected that more errors are made in the speed episode trials than in the accuracy trials before that. Additionally, based on the research by Gas and colleagues (2018) and Weimer (2019), we expect that in the accuracy trials after the speed episode, a decrease in time on task can be observed. This decrease cannot be observed in a group that is restricted to accuracy trials. It is also expected that the accuracy measure(s) in the speed condition will be similar to or better than the control group in the third block of trials.

The second research question is: To what extent are skills learned in the driving simulator be retained after 1 week? Based on the above considerations of the retention literature, it is expected that the skills learned in one session can be retained. The second session will be placed at approximately one week after the first one. This is based on current driver training in the Netherlands where learners often drive once or twice a week. No expectation can be shared about an effect of the speed episode effect on retention. This has not been previously researched, and this question is therefore left open. The only expectation is that skills are retained (almost) fully for both conditions.

2. Method

2.1 Participants

Participants were gathered via convenience sampling and were randomly divided over the conditions. Ten participants with an average of 22 years participated in the accuracy condition. Four of them had driving lessons in the past, and one participant had a driver's license. The participant with the driver's license is considered an experienced driver, due to driving weekly and having extensive experience in driving in many foreign countries and in different weather conditions. The participant never had a crash with a car.

Ten participants with an average of 21 years took part in the speed condition. Six participants had driving lessons, but only two had a driver's license. One of those was considered a moderately experienced driver because the participant had a driver's license for 7 years but only drove rarely, did not own a car and had never driven in a foreign country, nor had driven in many different weather conditions. The other participant with a driver's license was considered an experienced driver because the participant drove weekly, owned a car, and had extensive experience in driving in all different types of weather conditions. Both drivers never had a car crash. Ethical approval for this study was provided by the Ethics Committee for Behavioural and Management Sciences at the University of Twente.

2.2 Materials

2.2.1. Online driving simulator

The online driving simulator environment was provided by Green Dino (https://www.greendino.nl/). The virtual environment could contain up to 21 visual models and contained a logic 3D Roadnet. It also had the possibility to add virtual agents, which included other cars, bicyclists and pedestrians. In the experiment only pedestrians were used, so there was no other traffic. See Figure 2 for a screenshot of the simulator when participants were driving it. Participants could log in on their own computer via an internet portal to download the software on their computer. This was only compatible with the Windows operating system, and a computer mouse had to be used in order to control the car in the game. Moving the mouse forward resulted in acceleration, moving the mouse down in deceleration, and left and right controlled the steering wheel direction. Clicking the mouse

Figure 2. Online Driving Simulator

buttons controlled the indicators. The left and right arrow, or the z and c keys, were used to open a viewport which displayed the mirrors and a view to the left and right of the car.

2.2.2. Informed consent

The informed consent was administered via Qualtrics. The informed consent was two-part and provided in Dutch with an information sheet and a consent form (see Appendix A).

2.2.3. Pre-questionnaire

The pre-questionnaire was developed specifically for this study, as there was no existing questionnaire that fit the purposes of this study (see Appendix B). Questions were asked to gather demographic information on age, gender and country of origin as well as information about the driver experience of participants, such as whether they had a license and if they ever had driving lessons.

2.2.4. Remote communication:

Skype and WhatsApp were used for communication. Skype was used to welcome the participants and explain the procedure of the experiment to them. Since the driving simulator software and Skype could not be active at the same time, it was decided to use WhatsApp for (video)calling while the simulator was used. WhatsApp was be used on a mobile phone. This led to a stable way of communication during the experiment. If using WhatsApp was not possible, a regular phone call was made to stay in touch with the participants and give directions. Additionally, TeamViewer was used to be able to observe the screen of the participant remotely and to note any issues that occurred during the experiment. This allowed the researcher to control the screen of the participant in order to either fill in passwords or to troubleshoot in case of issues.

2.3 Procedure

Participants were recruited via the personal networks of the involved researchers. Participants were required to participate in two sessions. They had two options with regard to data collection: remote or in-person. Remote data collection took place via a video conference using Skype and WhatsApp. To control what happens during the experiment and to troubleshoot the simulator TeamViewer was used. For remote data collection participants received instructions to install the software and run it. In-person data collection took place in the home of the researcher or the participant with adherence to healthy safety rules concerning COVID-19. In Session 1 participants opened Qualtrics to read an information sheet that explained, amongst other things the purpose of the study. After the information sheet they read the informed consent. Participants agreed to the informed consent by ticking a box in Qualtrics stating they read the informed consent form, understood it, and agreed to it. Then they were asked to fill in the pre-questionnaire. Afterwards participants continued to the online driving lesson environment.

Participants were divided into two groups, who both participated in 4 blocks of trials divided into two sessions. The only practice trial was a single round on the ‘Introduction’ module to get used to the controls. There were two types of trial blocks: accuracy training and speed training blocks. Table 1 contains an overview of the type of trial per condition and per session.

The lesson ´Introduction´ was used for all routes used in this study, but two different software versions were generated. Each lesson consisted of two trials. For both versions this lesson contained no other traffic, such as other cars, it contained speed limit signs and allowed participants to drive in different environments, e.g. urban area with a maximum speed of 30km/h vs. rural area with a maximum speed of 80 km/h. Both conditions also contained people/children that could cross the road in an urban area. The speed condition version also had a bus that was parked at a bus stop on the map. The route on the map was randomised each trial and had a length of 2 kilometres. After the first iterations in the simulator it was decided to set the number of trials at 8, so as not to exceed the total time of 2 hours for the first session and to prevent the participants from getting too tired. After the first session, most participants indicated feeling exhausted.

Table 1

Set-Up of Blocks and Trials per Condition per Session

Session	Block	Accuracy condition	Speed condition
1	1	Accuracy *8 trials*	Accuracy *8 trials*
	2	Accuracy *8 trials*	Speed *8 trials*
	3	Accuracy *8 trials*	Accuracy *8 trials*
2	4	Accuracy *10 trials*	Accuracy *10 trials*

For the accuracy blocks participants received the following instruction: "*You will now drive 8 (more) trials. Drive as you would on a normal road in real life*". In an accuracy trial a virtual instructor provided information on how to act in a specific situation and gave feedback about mistakes. This was representative of current driver training in the Netherlands. Navigational instructions were provided by arrows in the right bottom corner of the PC screen (see Figure 2). If there were no navigational instruction participants were instructed to drive straight ahead. If the instructions overlapped making it unclear what the right instruction was, participant were allowed to choose which way they wanted to go. Participants in the speed trials were provided with the following instructions: "*We are now interested in your driving behaviour in a different environment. You will now complete 8 more trials in this environment. Try not to focus on avoiding mistakes, rather try to drive a trial as fast as possible*" In the speed trials there was no guidance or feedback at all about the driving behaviours. This was used on top of the verbal instructions to stimulate speeding up. Furthermore, there were no speed limit signs in order to further stimulate speeding up. Once again, navigational instructions were provided in the right bottom corner.

Participants were required to participate in Session 2, which took place 5-7 days after Session 1. The second session was aimed at testing the retention of skills learned in the first session. Participants drove 10 accuracy trials, which had the same features as mentioned for Session 1. They received the following instruction: "*You will now drive 10 trials. Drive as you would on a normal road in real life.*" The choice was made not to include a block where participants could get reacquainted with the simulator, as this might also start the learning process again. Therefore, the number of trials was raised to 10 in order to account for this reacquaintance phase.

2.4 Design and measures

2.4.1. Design

A between-subjects design was used to observe the effect of the independent variable Training Group (Accuracy Group x Speed Group) on the dependent variables Time on Task (ToT) and number of Crashes. In the *Accuracy group* participants only focused on accuracy for all trials. In the *Speed group,* participants drove a block of speed episode trials in between blocks of accuracy trials. Additionally, a comparison was also made at the individual level.

2.4.2. Measures

The following list of performance measures were taken from the raw simulator data:

- <u>Time on task (ToT):</u> This was a measurement for the performance parameter time and was logged in seconds. This was determined by taking the starting point as the moment the participant started driving and the finish is the end of a 2km route.
- <u>Number of Crashes:</u> This was a measurement for the performance parameter accuracy. Respawns were considered an error, because they occurred when a car collided with another object, including buildings, or when the car got off the road. This is an error because in real life, these incidents are actually considered as accidents and can lead to damage on a car and injuries.

2.5 Data analyses

Demographic information was analysed using IBM SPSS Statistics v25. Data gathered from the simulator was analysed in a number of ways. The analysis was done in the programming language R. In R, the following libraries were used: Haven, readxl, ggplot 2, dplyr, tidyr, regression:rstanarm, brms, mascutils, and bayr (github)(see Appendix D for the R code). Data was first visualised using boxplots and scatterplots. If needed, outliers were removed and data was filtered in order to clean up the data set. This was followed by a linear regression analysis for ToT and accuracy measures to check whether the SAT was observed in the online driving simulator.

For the number of crashes a Poisson Generalised Linear Model was used. This model was the best fit because it assumes that the number of crashes is bound at zero, meaning that you are able to score a 0 on the measure, which is true. It also assumes that the linear predictor is exponential, which fits with the literature discussed above. For ToT an ExGaussian Regression Model was employed. It does not assume that ToT can be zero, which holds for our study, because you cannot drive a lap in 0 seconds, the minimum probably lies at around 60 seconds. The ExGaussian model, like the Poisson model, assumes that the data is exponential rather than linear. This entails that they more accurately reflect real data, as linearity is not assumed for real data (Schmettow, 2020).

For individual level analyses first a look was taken at the multilevel plots which displayed the distribution of performance measures per individual. Then a look was taken at whether there were differences between experienced and unexperienced drivers. This should be visible in the individual plots.

3. Results

The following things are discussed below. First, outliers and missing values are mentioned in order to explain how the final dataset was established. Then analyses regarding the speed-accuracy trade-off are discussed in order to determine whether it could be observed. Then the analyses focus on the population level in order to compare performance between the conditions. Finally, we discuss analyses at the individual level in order to compare individual performance.

3.1 Outliers and missing values

Two participants were removed from the data analysis, both participated in the Accuracy group. Participant 7 dropped out due to malfunctioning software via remote data collection and self-reported feelings of nausea. Participant 15 indicated that after 3 trials he was getting very frustrated and upset, at which point the researcher decided to stop the experiment to prevent further frustration. A look was also taken to see whether the participants 5, 8 and 17 with a driver's license performed differently from the participants without a driver's license. The experienced drivers did not perform differently from the other participants as can be observed in the individual level scatterplots. This is further discussed below in the individual analyses. Additionally, there were a number of missing values due to miscounts of the researcher or errors in logging the data. Also, some trials, such as Trial 20 for Participant 1, were removed because of errors in the simulator. In this particular case the simulator noted a car crash and showed this on the screen although the participant had not crashed the car. Based on the boxplots (see Appendix C, Figure 9 and 10), it was observed that there were no outliers in the data.

3.2 Speed-accuracy trade-off

In order to determine whether the speed episode effect could be observed, first the speed-accuracy trade-off had to be present. A linear regression model was used to analyse this for both groups in Block 2. Figure 3 provides a visualisation of the speed-accuracy trade-off. A clear downwards slope can be distinguished, which displays that the longer the ToT, the lower

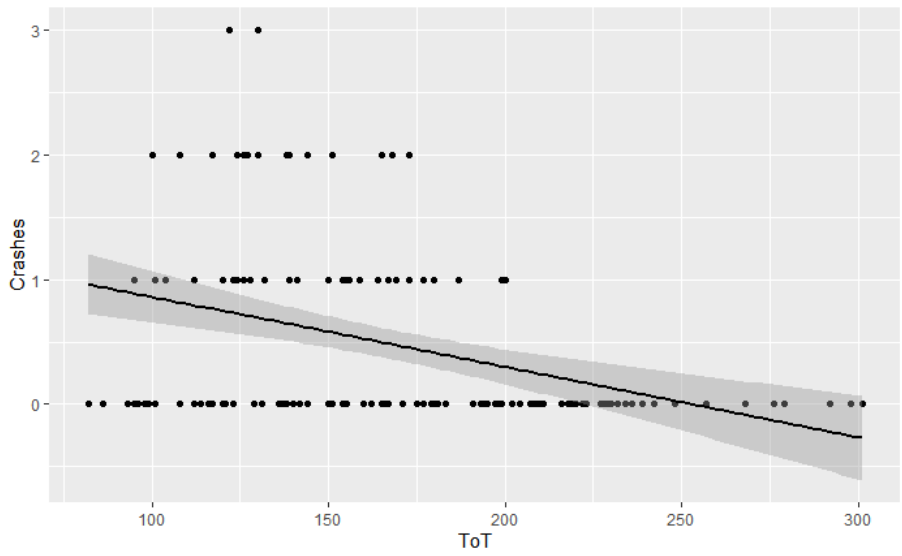

Figure 3. Linear regression plot for the speed-accuracy trade-off in Block 2 across both groups. The measure ToT is in seconds.

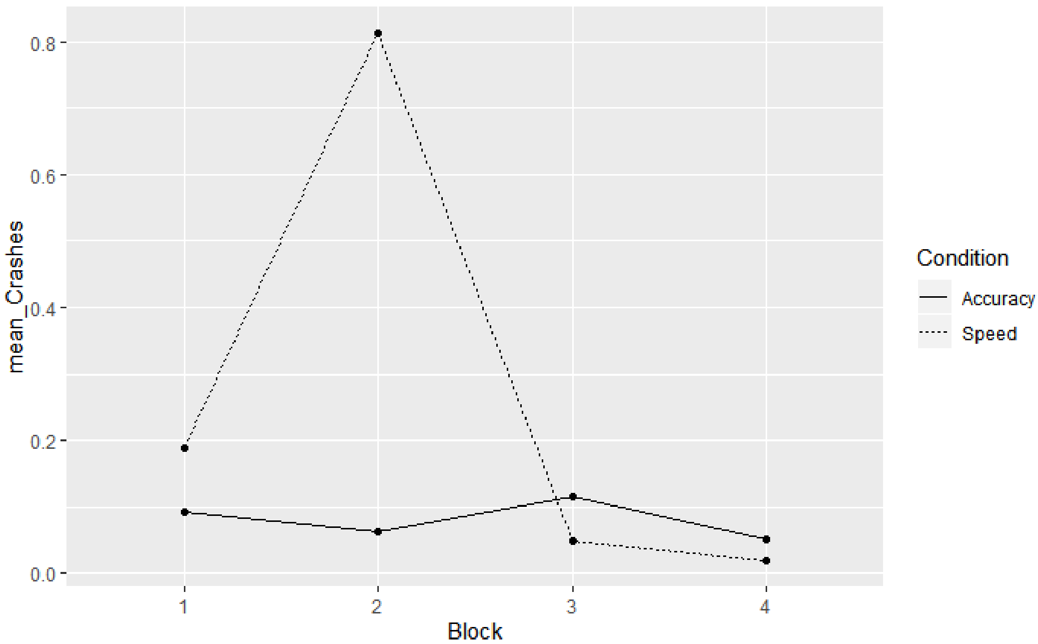

Figure 4. Mean number of crashes per Block and per Condition at the population level. Block 1 to 3 belong to Session 1, Block 4 belongs to Session 2.

the number of crashes. The linear regression model further predicts that a crash decreases the ToT by 23 [-33, -13]$_{CI95}$ seconds. These result confirm the existence of the speed-accuracy trade-off. This is also reflected in Figure 4, which displays the mean number of crashes at the population level per block divided over the groups. The figure clearly displays that most participants in the speed block crashed considerably more compared to the accuracy block. On average participants in the accuracy group crashed .115 times per trial in Block 2, versus .813 times per trial for participants in the speed group. This confirms the SAT in Block 2.

3.3 Population level analyses

First, differences at the population-level for ToT and the number of crashes were analysed in order to test the effect of the speed episode on the performance variables. A look is taken at the posterior predictions and confidence intervals. Additionally, a look is taken at the differences within a group. Figure 4 and 5 provide a visualisation of the measures ToT (in seconds) and number of crashes per block and condition at the population level. It can be observed in Figure 5 that most participants in the speed group show a strong decrease in ToT in Block 2, which can be described as a trough.

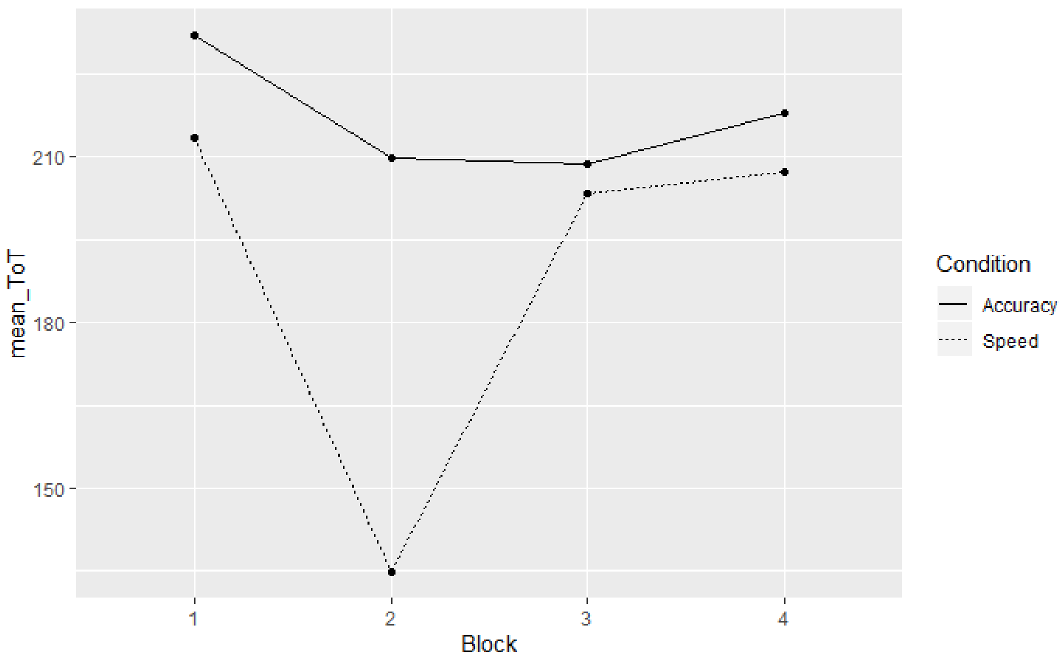

Figure 5. Mean ToT in Seconds per Block per Condition at the population level. Block 1 to 3 belong to Session 1, Block 4 belongs to Session 2.

Table 2

Mean Time on Task (ToT) in Seconds and Differences in Number of Crashes With Confidence Intervals Between Blocks Within a Condition at the Population Level

	Accuracy Group		Speed Group	
Block	*ToT*	*Crashes*	*ToT*	*Crashes*
1	228 [220, 237]	.077 [.028, .166]	214 [206, 221]	1.679 [.515, 5.272]
2	209 [201, 218]	.687 [.170, 2.448]	137 [130, 145]	8.786 [2.008, 45.199]
3	210 [201, 218]	1.088 [.335, 3.414]	205 [198, 212]	.211 [.039, 1.060]
4	215 [206, 223]	.457 [.106, 1.570]	209 [202, 215]	.226 [.031, 1.571]

Note. Confidence interval is 95%.

In Table 2 the posterior predictions and confidence intervals for ToT (in seconds) are provided following an ExGaussian Regression Model. When comparing the groups in Block 1, it can be observed that there is a small difference in basic performance. This entails that although all participants only drove accuracy trials, there is a basic difference of roughly 14 seconds between the groups, which is considerable as the confidence intervals are not very wide. Block 2 displays a big difference between the groups that can be attributed to the speed instruction. On average, participants in the Speed group were 72 seconds faster per trial in Block 2 than participants in the Accuracy group. Participants in the Accuracy group improved their ToT by 19 seconds in Block 2. This means that participants in the Speed Group improved just under a minute on their ToT when taking into consideration the learning that occurred in the Accuracy group. In Block 3, participants from the Accuracy group did not reduce their ToT as the population level average stayed almost the same at 210 seconds. Participants in the Speed group reduced upon their ToT by 9 seconds compared to Block 1, which is a small difference. Compared to the Accuracy group, there is a difference of 5 seconds in advantage of the Speed group, which is very small. Block 4 was aimed at testing the retention of skills. On average participants in the Accuracy group took 210 seconds to complete a trial in Block 3. They were 5 seconds slower per trial in Block 4. This entails that they were able to retain 97.7% of their skills regarding ToT. The Speed group had an average of 205 seconds per trial in Block 3. This mean population level score was raised to 209 seconds in Block 4. This means that they were able to retain 98.1% of their ToT performance. Additionally, the values in the confidence intervals of Block 3 and 4 overlap, meaning that the differences are not significant. It can be stated that all confidence intervals for the measure ToT in Table 2 are narrow, meaning that there is not a lot of uncertainty about the results.

Table 2 also shows the number of crashes as an indicator for accuracy. The data on crashes are assumed to follow a Poisson distribution, meaning that the data in Table 2 should be interpreted as a multiplicative interpretation. In Block 1, the Accuracy group produced .078 times the number of crashes compared to the Speed group. In Block 2 the Accuracy group reduced the number of crashes by factor 0.7. In Block 3, the number of crashes is increased by factor 1.1. In Block 4, it reduces again by factor 0.5. This entails that in the first block, participants in the Accuracy group crashed less than participants in the Speed group. In the second block they managed to moderately reduce the number of crashes, which slightly increased again in the third block. In Block 4, participants from the Accuracy group managed to crash less. This shows that participants in the Accuracy group were able to retain all of their skills with regards to crashes and actually improved their skills. The confidence intervals for Block 2 and 3 are very wide, meaning that there is a lot of uncertainty about the data and no major conclusions may be drawn about those blocks.

For the Speed group the following observations can be made. In Block 1, the participants produced 1.7 times more crashes than the Accuracy group. In Block 2 the number of crashes was increased by factor 8.8 compared to Block 1. In the Block 3 the number of crashes was reduced by factor 0.2 and in the Retention block (Block 4) by factor 0.2 compared to the respective previous block. This means that participants in the Speed group on average crashed more than the Accuracy group. In the second block, as a result of the SAT, the number of crashes was much higher compared to the first block. In the following blocks this number decreased again. With regards to retention, participants were able to fully retain their skills with regards to the number of crashes and were even able to improve upon these skills. However, the confidence intervals for Block 1 and, especially, Block 2 are very wide, meaning that no big conclusions can be drawn from that data.

3.4 Individual level analyses

As could be observed in Figure 4 and 5, participants varied a lot in their performance. So, analyses were performed at the individual level in order to investigate how individuals exhibit different behavioural patterns within the experimental manipulation. More specifically, we are interested in whether there are differences between experienced and unexperienced drivers as an underlying factor influencing performance. In this study Participant 5, 7 and 18 are participants with a driver’s license and thus have considerable experience. Figure 6 shows that those participants display the expected patterns of behaviour based on the expectations raised by the population level analyses. Participant 5 belongs to the Accuracy group and displays a steady decrease in ToT. The other participants belong to the Speed group and display the trough in ToT. They also show the expected patterns for Crashes (see Appendix C, Figure 11). Despite not having a driver’s license, there were a number of participants that did have driving lessons in the past, meaning that they were not fully unexperienced. Figure 7 shows the scores for the mean ToT in seconds per Participant. Participant 4 and 18 shows some unexpected patterns. Participant 4 from the Speed group does not display a trough and shows a moderate increase in ToT in Block 3, putting the average above the Block 1 average. Participant 18 showed slight increase in ToT which was steady over the blocks, whereas this should have been a decrease. With regards to the average number of Crashes, it can be stated

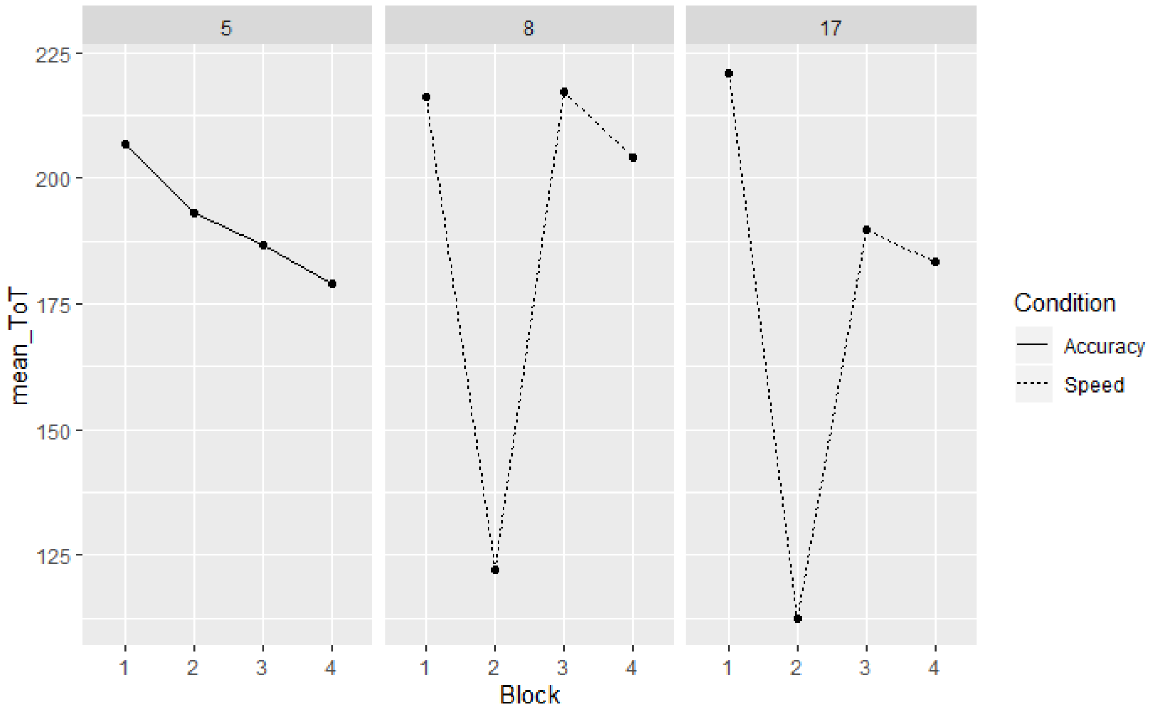

Figure 6. Mean ToT in seconds per Block per Condition per Participant with a driver's license.

that most participants from the group with driving lessons but without a driver's license show the expected patterns (see Appendix C, Figure 12). Participant 4 did display an increase in the average number of Crashes in Block 2, but did not have the clearly visible peak of the other participants. There was also a group of participants that were completely unexperienced (see Figure 8). In this group Participant 3, 9, and 10 show some deviating patterns. Participant 3 has a very high ToT in Block 4, whereas only a slight increase in ToT was expected. Participant 9 belongs to the Accuracy group where a slight decrease in ToT over the blocks was expected, but the scores seem to remain stable throughout all blocks. Participant 10 from the Speed group did not display the trough unlike the other participants. With regards to the number of Crashes it could be observed that there is a lot of individual variety within the data (see Appendix C, Figure 13). For example, Participant 10 from the Speed group displays a very large number of Crashes in Block 1, therefore a peak in Block 2 is not visible.

So, it was observed that most participants show the same patterns of behaviour. This is not heavily influenced by having a driver's license or having had driving lessons. There are some participants that stand out, which is to be expected in this type of research and is not a cause for concern.

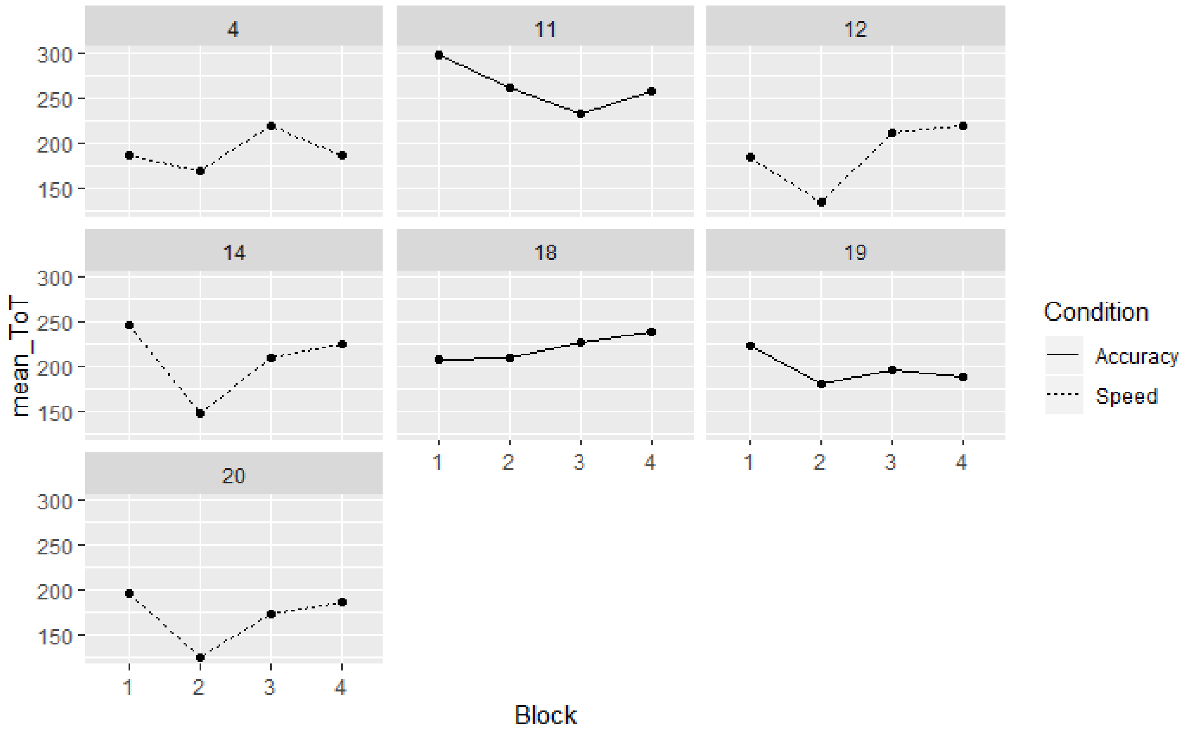

Figure 7. Mean ToT in seconds per Block per Condition and per Participant with driving lessons, without a driver's license.

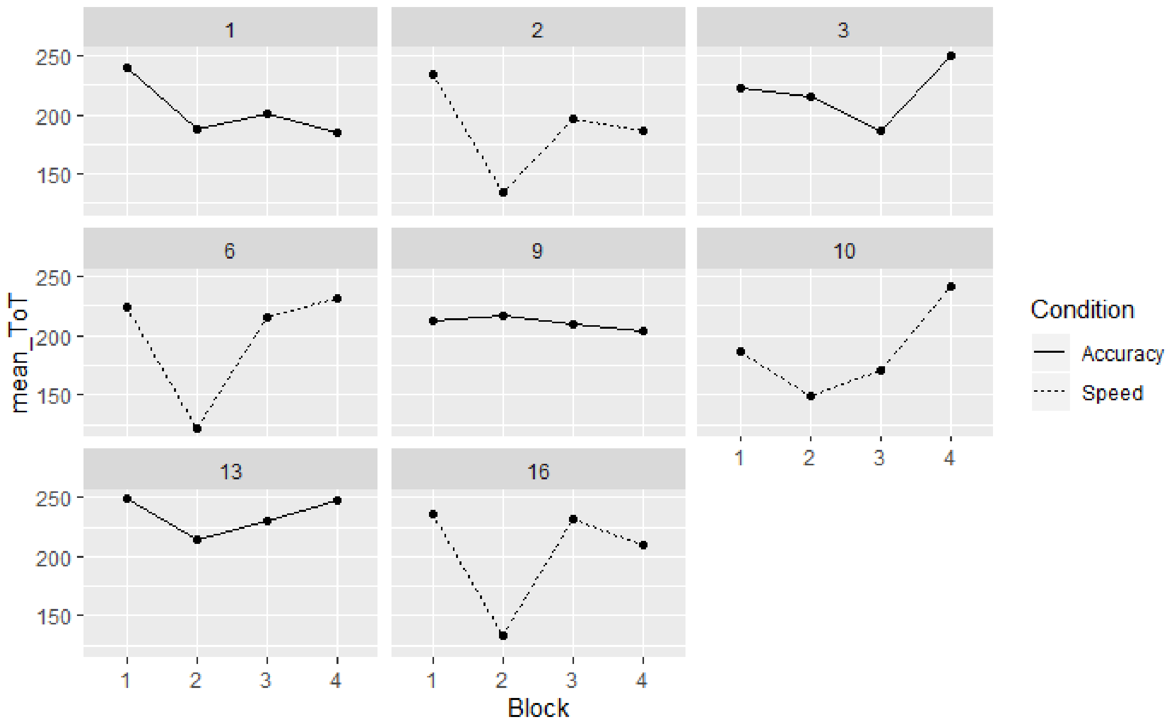

Figure 8. Mean ToT in seconds per Block per Condition per Participant without a driver's license or participation in driving lessons.

4. Discussion

The aim of the study was to analyse the effect of speed episode training on the performance variables Time on Task (ToT) and number of Crashes in an online driving simulator. In total 18 participants eventually took part in the study, of which three had a driver's license. Their data did not differentiate from the data of other participants as could be observed in the individual analyses. A look was taken at whether the speed-accuracy trade-off (SAT) could be observed, whether a speed episode effect was observable, and whether the skills learned in Session 1 could be retained for one week to Session 2. Together, this led to an assessment of the success of the experimental manipulation and the effectiveness of speed episode training.

The first research question aimed to determine whether the speed episode training had an effect on performance in the simulator. A speed episode can only be established successfully if the SAT can be manipulated. Therefore, it first needed to be investigated whether a SAT was present in the simulator. The results showed the presence of the SAT. Every time the participant crashed, this gained them approximately 23 seconds in terms of ToT. This is in line with what is known about the SAT (Wickelgren, 1977; Zimmerman, 2011). The data also showed that the manipulation of the SAT was successful, as could be seen in a trough in ToT and peak in crashes in the speed episode. This is in line with the expectations based on previous research by Weimer (2019). Then, it needed to be determined whether the speed episode effect could be observed. The effect could not be observed in the data on ToT and the number of Crashes. The difference between the Accuracy and Speed group was only 5 seconds, which is not noteworthy and did not reach statistical significance. With regards to crashes, the difference was also not noteworthy. This was further confirmed by the fact that there were no differences between experienced and non-experienced drivers, where they should have been in the case of the speed episode effect. This is not in line with findings in previous research (Gas et al., 2018; Weimer, 2019). A possible explanation for this might be that the skills learned in the study are not motor skills, because controlling the mouse was not a complicated motor skill to master. A lot of people have used or use a mouse in daily life when operating a computer, which could explain the lack of differences between the experienced and unexperienced drivers.

Secondly, it was investigated to what degree skills learned in the simulator could be retained after a 1 week period. Participants were able to retain at least 95% of their skills regarding ToT. All participants were able to fully retain their skills regarding the number of crashes and they were able to improve upon them. These findings are in line with the previously discussed forgetting model (Kim & Ritter, 2015). Additionally, the findings add to other evidence that procedural skills in simulators are hardly forgotten (Mitchell et al., 2011; Moktar et al., 2016; Stefanidis et al., 2008). Since the speed episode effect could not be observed, it also cannot be said whether the speed episode effect might have had an influence on how well skills are retained in an online driving simulator. It does mean that the results provide evidence that a driving simulator can be used to teach driving skills, because the skills that are learned are retainable. But, for this particular simulator, the speed episode training is not the best training method. However, it must be stated that the online driving simulator used in this study should not be used as the sole method of teaching. Being in a car provides additional sensory input, such as the feeling of taking a turn at excessive speed, which is important to fully grasp how to control and drive a car.

There are a number of limitations that need to be taken into account when interpreting the results discussed above. Firstly, it is possible that the measure ToT was disturbed by a command provided by the virtual instructor. The virtual instructor often stated that participants had to release the gas pedal because they were going over the maximum speed, although this was not always the case. Participants were instructed by the researchers to ignore this comment if they were certain that the speed limit was higher than they were driving. However, because the virtual instructor sounded very demanding and stern, he might still have influenced participants to drive slower where they were not supposed to, meaning that as a result their ToT was also longer. The way that participants handled this was not uniform in style, some participant ignored the virtual instructor and found him bothering, while others were intimidated and listened to his commands even though they were incorrect. This might have also been influenced by the fact that not all participants were aware of the traffic rules, including the speed limit. The researchers were able to observe this during the trials and because participants explicitly asked questions about it. So, this means that the measure ToT is not completely reliable. For future research it would be important to establish a more reliable measure for ToT, where participants, for example, do not receive vocal instructions on speed, but solely via speed signs. In such a situation, it would be useful to also add some basic traffic rule instructions in order for participants to have the same baseline knowledge with regards to speed limits and the meaning of signs.

A second limitation is that a computer mouse was used to learn motor skills. Since the control of the mouse was not very complicated, it could be that participants, as they also indicated, were busy learning more cognitively focused skills. Some participants indicated that they had difficulty trying to estimate depth or had difficulty trying to determine when to release the gas pedal and start braking in order to be able to stop in time for a red traffic light. Another disadvantage of using a mouse that it will most likely not results in a transfer of training. In order to create a transfer of training from an online driving simulator to driving a car on the road, intermediate steps should be taken. For example, the online driving simulator can be used to teach traffic rules and procedures about how to approach different situations. Then another simulator with a steering wheel and seat can be used to teach the basic motor skills used to drive a car. This then results in a driver that already has a lot of knowledge on traffic rules and basic motor skills when driving. This might reduce the amount of time spent in a car on the road to learn how to drive, while still ensuring people gather all the knowledge that they need.

Since the manipulation of the speed episode was successful, there might be potential in generating the speed episode effect in future research. Since actual motor skills were limited to controlling the mouse, it would be useful to employ a more realistic simulator, which would, for example, include an actual steering wheel. Another addition that would better simulate driving an actual car, would be either driving with VR glasses or to simulate the feeling of being in a car. A big part of driving a car is experiencing how a car reacts to certain actions. Some participants were able to take high speed turns in the simulator, roughly 45km/h, whereas in real life this would feel more risky as well as the sudden steering movement causing the driver to jolt in the car. This might cause future research to reflect more realistic driving behaviour data.

4.1 Conclusion

Based on the findings the following conclusions can be drawn. The SAT can be manipulated in a driving simulator by verbal instruction, so a speed episode can be created. The findings clearly show a trough in ToT and a peak in the number of crashes. A speed episode effect could however not be observed in the trials after the speed episode. All participants were able to retain most of their skills or even improve upon them. Currently, using speed episode training to improve the speed in the middle of the learning process rather than at the very end, is not effective. More research can be done in order to find the best way to incorporate driving simulators into driver training, such as with more realistic simulators. The most important part about driver training remains that people learning how to drive a car learn to do so in a safe environment so that they become skilled in situations that they might not come across often in real life when driving, but are essential to being able to drive safely.

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6. Appendices

Appendix A

Information Sheet and Informed Consent Form

Information sheet 'Online driving simulator' study

Purpose of the study

This study is led by Prof. Dr. Ing. W.B. Verwey.

The goal of the study is to investigate individual learning behaviour in a driving simulator. For this reason we are researching different training methods. It is therefore very important that participants are present for the 2nd session, in order to find out whether the skills learned in the 1st session can be retained.

Procedure

After informed consent has been given for participation in this study, we will begin with a questionnaire, followed by session 1. You will start with questions about demographic information and your driving experience in Qualtrics. After this some time will be dedicated to get to know the simulator and its controls. Then you will drive for 3 blocks consisting of 10 trials each. In between the blocks time is reserved for a small break. Session 1 is estimated to take 1,5 to 2 hours. 5-7 days after session 1 the second session will take place. You will drive 1 block consisting of 15 trials. Session 2 is estimated to take 30-45 minutes.

Potential risks and benefits

A potential risk is that you might collide with objects in the simulator, for example a car. This can cause discomfort. Please remember that these objects are fictional and that no harm can be done. Furthermore, there are no physical, psychological or economical risks when participating in this study. You are allowed to omit answers if you do not want to answer the questions. Your participation is on a voluntary basis and participation can be cancelled at any moment.

With regards to the COVID-19 virus, the researchers will adhere to the rules of the government, such as keeping 1.5 metres of distance. We kindly ask you to do the same. If you use the laptop of a researcher or you are both using the laptop during the study, the laptop will be disinfected.

Rewards

Participants do not receive a reward for this study.

Confidentiality and anonymisation of data

The researchers will do everything to protect your privacy. Confidential information or personal information will not be shared with third parties in any way. Before the research data are published, all information will be anonymised as much as possible, unless you explicitly provided consent for the mentioning of your name, for example in a quote.

A publication makes use of anonymous information. Any forms or other documents used or collected during the study will be stored at a secured location at the University of Twente and on the secured (encrypted) information storage of the researchers.

The data collected during the study will be retained for a minimum of 10 years in accordance with the regulations. At the latest at the passing of this date, all data will be deleted or fully anonymised until they are no longer traceable to a person.

Data will, when necessary (for example for control on scientific integrity), be shared anonymously with persons outside of the research group.

Finally, this research is evaluated and approved by the ethical committee of the BMS faculty at the University of Twente.

Voluntary basis

Participation in this study is on a voluntary basis. At any time a participant can stop the study or refuse the use of your data in the remainder of the study, without providing an explanation. Stopping the study does not have any negative consequences for you or consequences for any rewards that were received.

When you decide to quit the study, the data that were gathered up until that point will be used in the study.

If you want to quit with the study, or you have questions and/or complaints, please contact the lead researcher.

Lead researcher

Prof. Dr. Ing. W.B. Verwey

Email address: w.b.verwey@utwente.nl

Phone number: +31534894764

For any objections concerning the set-up or execution of the research you can also contact the secretary of the ethical committee of the Behavioural, Management, and Social Sciences faculty at the University of Twente via ethicscommittee-bms@utwente.nl. In case you have specific questions about the handling of personal information you can also pose these to the Data Protection Officer of the University of Twente by sending an email to dpo@utwente.nl.

Lastly, when you have a request to see, change, delete or adjust your data you can require this from the Lead Researcher.

Consent Form

‘Online driving simulator’ Study

I provide my consent to participate in the study ‘Online driving simulator’ which investigates individual learning behaviour, executed by the department Psychology at the University of Twente, Enschede.

I have been informed about the purpose of the study. I understand that my participation is on a voluntary basis. I am allowed to stop my participation at any moment, or withdraw my consent to use my data for the study, without providing clarification. Stopping the participation does not have any negative consequences for you. I have the right to receive a debrief about the general results of the study and I may request access to my personal results. I provide consent knowing that all aspects of my participation are confidential and that no harm will be done to me or that I will be misled.

I understand that the experiment might have benefits for trying to understand individual learning behaviour and supporting processes. The aim of this study is to understand how people and technology interact and how this interaction can be improved and optimised. It is possible that the results will form the basis for future research in the field of Human Factors and Engineering Psychology.

Appendix B

Pre-questionnaire

Demographic information

1. What is your age?

   ____

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

Driver experience

1. Have you ever had a driving lesson?
   a. Yes
   b. No
2. Do you have a driver’s license?
   a. Yes, for how long?_____________________________
   b. No
3. How often do you drive?
   a. Every day
   b. Every week
   c. Every month
   d. Rarely
   e. Not at all
4. Do you own a car?
   a. Yes
   b. No
5. Have you ever driven in other countries than the Netherlands or Germany?
   a. Yes, which countries? _____________________________________
   b. No.
6. Please tick all situations in which you have driven:
   a. 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

Appendix C

Additional Figures Results

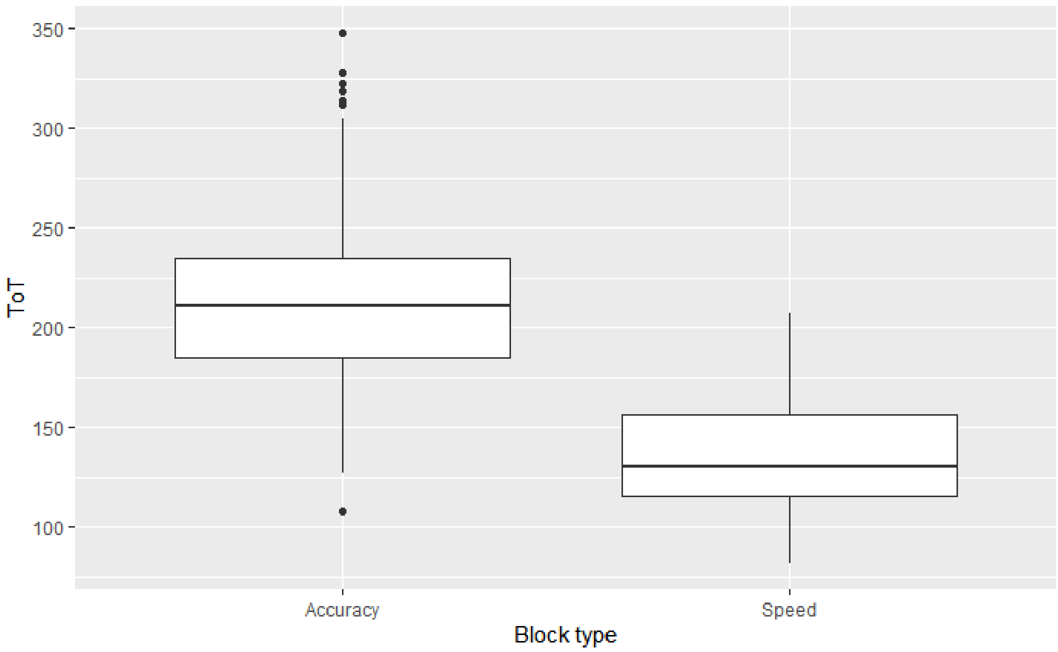

Figure 9. Boxplot of ToT (in seconds) distribution per block type.

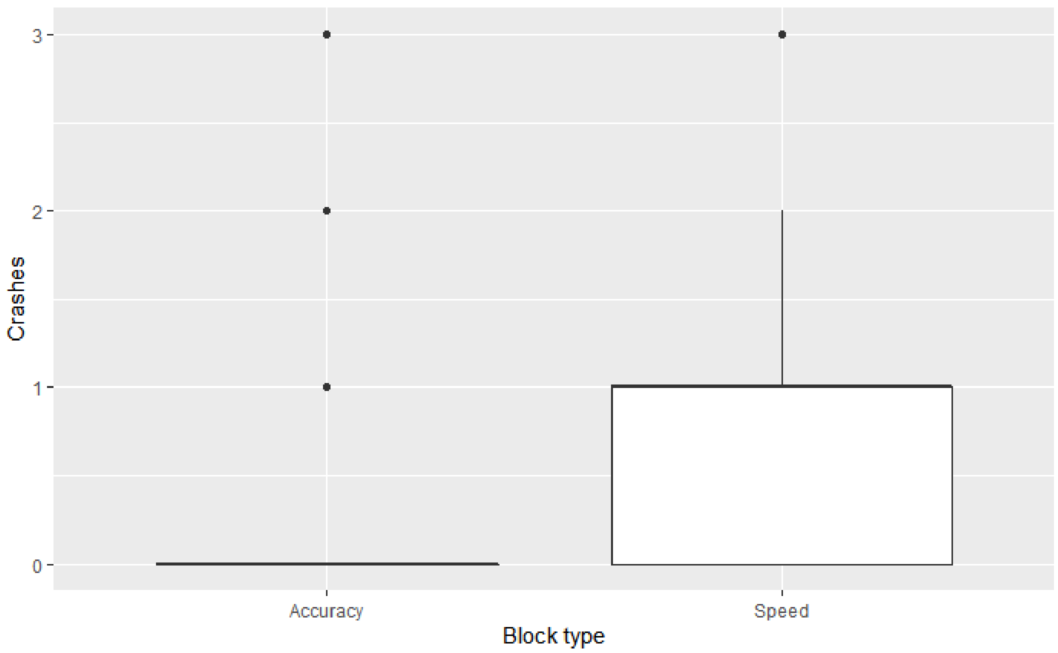

Figure 10. Boxplot of number of Crashes distribution per block type.

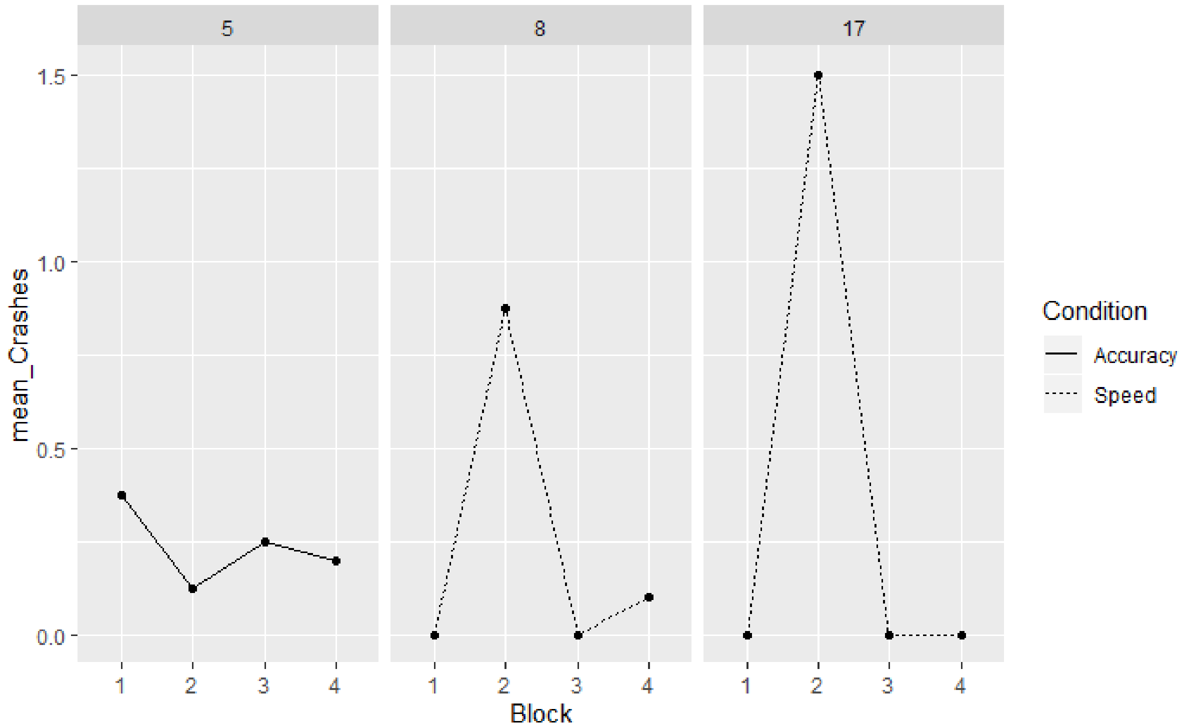

Figure 11. Mean number of crashes per Block per Condition for Participants with a Driver's License.

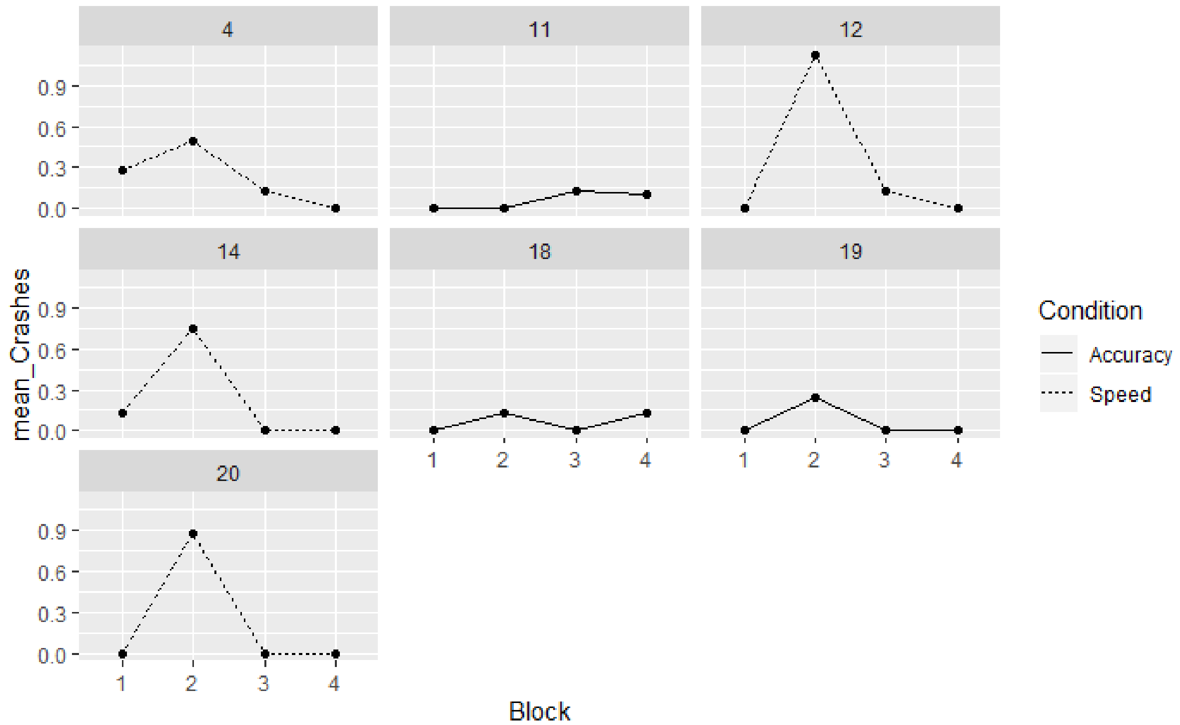

Figure 12. Mean number of crashes per Block per Condition for Participants without a driver's license but with driving lessons.

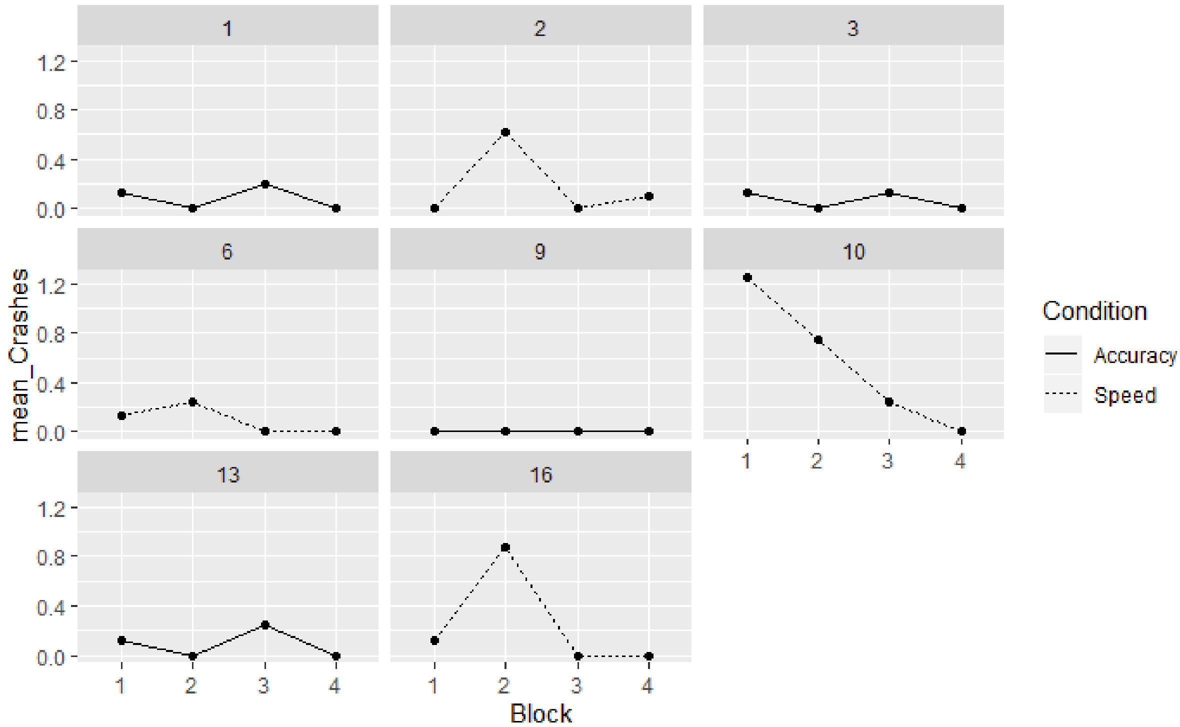

Figure 13. Mean number of crashes per Block per Condition for Participants without any experience.

Appendix D

R script

```
library(haven)
library(readxl)
library(ggplot2)
library(dplyr)

library(tidyr)
library(tidyverse)

library(rstanarm)

library(brms)

library(mascutils)

library(bayr)

D_1 <-
  read_csv("C:/Users/user/Documents/Psychology/Master/Thesis/Data/01 R/Rond
etijdendeelnemers.csv") %>%
  filter(ToT > 1) %>%
  mutate(Participant = as.factor(Participant),
         License = as.factor(License),
         Lessons = as.factor(Lessons),
         Condition = as.factor(Condition),
         Block = as.factor(Block))

D_1

D_2 <-
  read_csv("C:/Users/user/Documents/Psychology/Master/Thesis/Data/01 R/Mean
scoresperparticipantperblock.csv") %>%
  mutate(Participant = as.factor(Participant),
         Condition = as.factor(Condition),
         Block = as.factor(Block))

D_2

D_1 %>%
  ggplot(aes(x = `Block type`, y = ToT)) +
  geom_boxplot()
```

```
D_1 %>%
  group_by(Condition, Block) %>%
  summarize(mean_ToT = mean(ToT, na.rm = T),
            sd_ToT = sd(ToT, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_ToT,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))
```

```
D_1 %>%
  group_by(Condition, Block) %>%
  summarize(mean_Crashes = mean(Crashes, na.rm = T),
            sd_Crashes = sd(Crashes, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_Crashes,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))
```

```
D_1 %>%
  ggplot(aes(x = `Block type`, y = Crashes)) +
  geom_boxplot()
```

```
D_1 %>%
  ggplot(aes(x = `Block type`, y = ToT)) +
  geom_violin()
```

```
D_1 %>%
  ggplot(aes(x = `Block type`, y = Crashes)) +
  geom_violin()
```

```
D_2 %>%
  group_by(Condition, Block) %>%
  ggplot(aes(x = Block, y = ToT_mean, group = Participant)) +
  geom_point() +
  geom_line(aes(linetype = Condition))
```

```
D_2 %>%
  group_by(Condition, Block) %>%
  ggplot(aes(x = Block, y = Crashes_mean, group = Participant)) +
  geom_point() +
  geom_line(aes(linetype = Condition))


D_Block2 <- subset(D_1, Block == 2)

D_Block2 %>%
  ggplot(aes(x= ToT, y = Crashes))+
  geom_point() +
  stat_smooth(method = "lm", col = "black")
```

```
Model_LM_ToTCrash <-
  D_Block2 %>%
  stan_glm(ToT ~ 1 + Crashes,
           data = .)

T_M_LM <- coef(Model_LM_ToTCrash)
T_M_LM

D_1 %>%
  group_by(Condition, Block) %>%


D_1 %>%
  ggplot(aes(x = Crashes)) +
  geom_histogram()
```

```
M_1_Crash <-
  stan_glm(Crashes ~ 1,
           family = poisson,
           data = D_1,)

fixef(M_1_Crash)

fixef(M_1_Crash, mean.func = exp)

M_Crashes <-
  stan_glmer(Crashes ~ Condition + Block + Block:Condition +
               (1 + Condition + Block|Participant),
             family = poisson,
             data = D_1)

fixef(M_Crashes, mean.func = exp)

D_1_mod <- D_1 %>%
  filter(!is.na(ToT)) %>%
  as_tbl_obs()


F_1 <- formula(ToT ~ 0 + Condition:Block)


memory.limit(32000)

M_ToT_exg <- D_1_mod %>%
  brm(F_1,
      family = exgaussian,
      data = .)

fixef(M_ToT_exg)
```

```
D_1 %>%
  group_by(Condition, Block, Participant, License) %>%
  summarize(mean_ToT = mean(ToT, na.rm = T),
            sd_ToT = sd(ToT, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_ToT,
             group = License)) +
  geom_point(aes(shape = License)) +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_License <- D_1[D_1$Participant %in% c(5, 8, 17),]

D_License %>%
  group_by(Condition, Block, Participant) %>%
  summarize(mean_ToT = mean(ToT, na.rm = T),
            sd_ToT = sd(ToT, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_ToT,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_License %>%
  group_by(Condition, Block, Participant) %>%
  summarize(mean_Crashes = mean(Crashes, na.rm = T),
            sd_Crashes = sd(Crashes, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_Crashes,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_1 %>%
  group_by(Condition, Block, Participant, License) %>%
  summarize(mean_Crashes = mean(Crashes, na.rm = T),
            sd_Crashes = sd(Crashes, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_Crashes,
             group = License)) +
  geom_point(aes(shape = License)) +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_1 %>%
  group_by(Condition, Block, Participant, Lessons) %>%
  summarize(mean_ToT = mean(ToT, na.rm = T),
            sd_ToT = sd(ToT, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_ToT,
             group = Lessons,)) +
  geom_point(aes(shape = Lessons)) +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_Lessons <- D_1[D_1$Participant %in% c(4, 11, 12, 14, 18, 19, 20),]

D_Lessons %>%
  group_by(Condition, Block, Participant) %>%
  summarize(mean_ToT = mean(ToT, na.rm = T),
            sd_ToT = sd(ToT, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_ToT,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_Lessons %>%
  group_by(Condition, Block, Participant) %>%
  summarize(mean_Crashes = mean(Crashes, na.rm = T),
            sd_Crashes = sd(Crashes, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_Crashes,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_Unexperienced <- D_1[D_1$Participant %in% c(1, 2, 3, 6, 9, 10, 13, 16),]

D_Unexperienced %>%
  group_by(Condition, Block, Participant) %>%
  summarize(mean_ToT = mean(ToT, na.rm = T),
            sd_ToT = sd(ToT, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_ToT,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_Unexperienced %>%
  group_by(Condition, Block, Participant) %>%
  summarize(mean_Crashes = mean(Crashes, na.rm = T),
            sd_Crashes = sd(Crashes, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_Crashes,
             group = Condition)) +
  geom_point() +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```

```
D_1 %>%
  group_by(Condition, Block, Participant, Lessons) %>%
  summarize(mean_Crashes = mean(Crashes, na.rm = T),
            sd_Crashes = sd(Crashes, na.rm = T)) %>%
  ggplot(aes(x = Block,
             y = mean_Crashes,
             group = Lessons)) +
  geom_point(aes(shape = Lessons)) +
  geom_line(aes(linetype = Condition))+
  facet_wrap(~Participant)
```