Measuring the Effectiveness of Simulator Hazard Perception Training on Driving Performance: A Survey Study

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Abstract

Background: Road fatalities, such as car crash involvements, are a recurring problem in all countries, especially among young inexperienced drivers. Underdeveloped *hazard perception skills* (Anticipating dangers on the road) is one of the most crucial individual factors for accidents to occur. Thus, it is imperative to investigate how these fatalities can be prevented through effective training of driving pupils, specifically focused on hazard perception skills. Nowadays, driving simulators have shown to act as an incentive in driving training. Therefore, the aim of this survey study was to explore to what extent simulator hazard perception training is transferrable to real driving performance on the road.

Methods: To explore the effects of simulator hazard perception training, a survey study was conducted, this was in association with the simulator company *Green Dino*. The simulator hazard perception training consisted of several trials with a dangerous situation to which the trainee had to anticipate. Consequently, this was corroborated with feedback. Ultimately, 1.442 respondents that followed this simulator training in 2015 filled in this survey.. The primary expectation was that drivers without simulator hazard perception training would be more involved in accidents and be more eager to engage in risky behaviour such as driving too fast. Moreover, this main expectation was measured with the outcome variables (1) *accident involvement (first and last year), (2) first pass driving exam* and (3) *risky behaviour (first and last year).*

Results: Ultimately, there was no significant predictive effect of hazard perception training on the variables accident involvement, first pass driving exam and risky behaviour. This can be possibly caused by weakened validity of data, due to the self-reported measurement. However, the outcome variable accident involvement in the first year approached significance ($p > .05$) and can therefore be considered as a trend.

Conclusion: In short, it is recommended to replicate the study, with the required improvements and different measurement, to accurately test the effects of driving simulators and hazard perception training.

Keywords: *Hazard perception training, Driving simulators, Traffic fatalities, FOV training (Field of View), Driving skills*

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1. Introduction

Over the years, road crashes and various other traffic accidents have become a serious problem globally. Although the Netherlands is known for its lowest number of traffic fatalities per inhabitant in comparison to other countries in the EU, the death rate concerning these fatalities increased by 1% (Raifman & Choma, 2022; Vlakveld, 2008). Moreover, according to Allen et al. (2007), novice drivers are the group that is mostly involved in road accidents and the number of traffic deaths. This can be a result of inefficient training on the road, inadequate exposure to a myriad of road situations and one of the most crucial factors within driving training: underdeveloped *hazard perception skills* (Cao et al.,2022).

Hazard perception (HP) can be conceptualised as the ability to perceive and anticipate traffic situations (Tūske et al.,2019; Horswill et al.,2021). Poorly developed HP skills can cause the driver to have difficulties with braking early enough if there is possible danger on the road. Consequently, these difficulties with slower reaction time can result in possible road fatalities. In addition to the driving experience, aspects such as cognitive functions such as visual attention and memory capacity are associated with developing these skills (Trick et al.,2012). In several EU countries, hazard perception tests are incorporated into driving training aimed at reducing road fatalities (Vlakveld 2008; Horswill, 2016). Nowadays, driving simulators are moderately being introduced as an incentive to train hazard perception skills in a risk-free environment. Although the significance of simulator training with the focus of reducing accident risks among drivers is not clear yet, a body of research asserts that driving simulator training increases passing rates and reduces accident involvement (de Winter et al., 2009; Underwood et al., 2011, Kuipers, n.d).

It is imperative that road accidents among drivers are prevented and that driving training prepares new drivers sufficiently to use their information-processing skills to anticipate dangers on the road. Moreover, as hazard perception training with simulators is becoming a trend in the driving training industry yet not evident, this study will examine *the effects of hazard perception simulator training on the driving performance of drivers*. This will be done by exploring several cognitive and information processing concepts (e.g., acquisition of driving skills) that affect the hazard perception of drivers. Furthermore, the effects and benefits of driving simulator training will be investigated to gain more knowledge on how to improve this kind of training in the future.

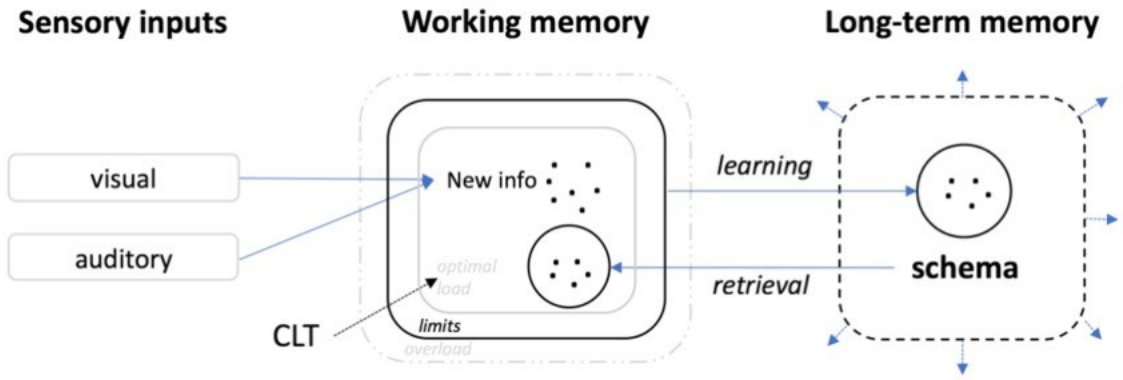
1.1 Mental Transition and Acquisition of Driving (HP) Skills

Acquisition of driving abilities, such as HP skills, can be discriminated among experienced and novice drivers, as both groups are skilled differently. For example, compared to experienced drivers, inexperienced drivers still need to train different driving skills to accurately apply them while driving on the road (Horswill, 2016). A theory that explains these differences in acquiring HP skills is the *Mental Transition Model (MT).* Firstly, regarding acquiring driving skills as novice driver, Kuipers & Wieringa (2018), proposed the *Mental Transition* model (MT), which involves the cognitive processes of short-term memory (STM), long-term memory (LTM) and working memory (WM) capacity. According to this study, the MT consists of different aspects, such as automation of skills, information capacity and motivation, that influence the acquisition of driving skills. *Automation of skills* is one of the main processes which entails the process of encoding information from STM to LTM, to automate certain (mainly vehicle operational) driving skills and enlarge capacity in STM to use for other cognitive processes, such as HP skills. This process happens swiftly and is therefore susceptible to inaccuracies from the driver's side (Kuipers & Wieringa, 2018). For example, inexperienced drivers will have more errors in mental transition than experienced drivers, as their nerve structures are not stimulated sufficiently. Therefore, inexperienced drivers need more training to enable the strengthening of processing skills, in this case, hazard perception skills.

In addition to the automation of skills, factors that assist in the mental transition process are crucial. For instance, the aspects of information complexity, sensory stimuli, intelligence, and motivation are crucial aspects that affect the MT process. Information complexity can occur when there is an invidual experienced information overload and can result in attention difficulties (Roetzel, 2019). Concerning the experience of the driver, these parameters are sufficiently managed by experienced drivers as their mental effort does not increase, which leads to an improved field of view. According to Vlakveld (2013), once nerve structures concerning the vehicle operational skills are more developed in their LTM, they have more time to attend to other aspects such as listening to music or paying more attention to environmental factors while driving. Additionally, inexperienced drivers have diminished situational awareness and visual allocation which affects predicting dangers due to their lack of cognitive skills (Vlakveld, 2013). Therefore, enhanced visual skills and appropriate management of mental effort increase the awareness of hazards in traffic situations.

Figure 1

Visualisation of the Mental Transition from Sensory Inputs to Long Term memory (Orru & Longu, 2019)



Correspondingly, Figure 1 depicts a visualisation of the transition process including the relevant cognitive factors of working memory and long-term memory. This figure corroborates the mental transition model of Kuipers & Wieringa (2018) specifically concerning the experience aspect of drivers. According to Orru & Longu (2019) expansion of the long-term memory results in greater space in WM capacity, which facilitates the processing of new information. This can be applied to the acquisition of HP skills in driving experience. Notably, experienced drivers are more able to pay attention to dangers on the road as their LTM is trained with sufficient knowledge, which means that there is more room created in their WM. In contrast, drivers without experience are still in the learning phase, therefore their WM takes up space with other driving aspects that still need adequate attention.

1.2 Importance of Hazard Perception Skill Training

Furthermore, there are several reasons why it is important that driving trainees gain sufficient hazard perception skills during their training. Horswill & Mckenna (2014) assert that underdeveloped hazard perception skills can empirically lead to increased crash-risk. Moreover, it is difficult to assess these skills, as acquisition particularly depends on experience. To illustrate, Horswill (2016) states that it can take years and experience to reach peak performance of hazard perception and that additional training can act as an incentive for decreasing the acquisition phase of hazard perception skills. Furthermore, a quick anticipation and identification of hazards demand knowledge and sufficient practice (Cao et al.,2022) Ultimately, the goals of improved hazard perception would be an efficient visual search of road situations and increased awareness of possible hazards (Allen et al., 2007; Horswill, 2016). In contrast to formal hazard perception training (HPT), which consists of

traditional teaching methods, such as watching videos of hazardous situations, it would be beneficial to add an engaging aspect in a realistic environment.

According to Newnam, et. al. 2013, HPT in combination with auditory feedback works more effectively. This specific commentary is often given after the trainee is presented with the hazardous task and results in a bigger training effect. Moreover, hazard perception training without engaging effect revealed non-significant results in the test-scores (Meir et al.,2014; Horswill, 2016). Therefore, the implementation of HPT on a simulator could act as an incentive in creating awareness of hazard perception skills. Additionally, creating negative emotion such as fear, can act as trigger and produce avoidance towards a dangerous situation (Zepf et al.,2019). This emotion would make the trainee unconsciously aware that they have to act to the situation. Research of Cao et al., 2022 has shown that additional training aspects such as auditory feedback and active engagement improves HP performance, which are aspects that are incorporated in simulator HP training.

1.3 Benefits of Driving Simulators and Different Applications of Driving Simulators within Driving Behaviour

Concerning the implementation of additional driving simulator training, research has provided information about the effectiveness of driver simulators and their appliance in driving training (Nahvi et al.,2022; Allen et al., 2007; Trappey et al.,2020). For example, Allen et al. (2007) assert that driving simulator training provides better insight into errors by providing instant feedback. A study of de Winter & Kuipers (2016) concurs with this notion and argues that simulator training consists of various visual and auditory sensations which are like real-world driving. Therefore, driving simulator training assists the trainees with gaining experience.

Field-of-view training (FOV) is a form of visual information management to educate driving trainees to accurately analyse the environment. This practice, in combination with hazard perception training, can assist in training the trainees to gain more reaction time and yields more strategic information adaption skills. Hence, this kind of training is in line with the mental model with regards to reducing the working memory load and making the transition to the LTM more swifty. Moreover, as appropriate appliance of visual attention is necessary with detecting hazards, FOV training can be an effective mechanism in this regard (Vlakveld, 2013). Results of FOV hazard perception training including automated feedback reveal that simulator trainees perform better on their first driving exam than trainees that follow simulator training without this process (Kuipers & Wieringa, 2018).

To illustrate, an example of a company that uses FOV hazard perception training with simulators is *Green Dino.* Simulators in a training setting are usually supplied with three screens, gas pedals, a moving driving seat and an adjustable steering wheel.

In the hazard perception training of *Green Dino*, trainees are presented with multiple hazardous situations in which a crash is provoked to which they must react without feedback. These situations are spread out over a total of five modules. Afterwards, automated feedback including correct instructions will be presented in visual and auditory form. Consequently, they will have to do the same scenario again with the right actions that they learned from the feedback. Moreover, these scenario's lower the self-esteem of the trainees, with as result to make them more unconsciously aware of the hazardous situation. Ultimately, they can use this self-awareness of skills to prepare themselves with the possible solutions to prevent a hazardous situation.

1.4 The Present Study

The present work aims to explore the effects of driving simulator hazard perception training on driving performance on the road with a survey study considering respondents who followed HPT. The main question that will be researched is: *Does hazard perception training in a driving simulator have transferrable effects in the real-world for drivers?* 'Transferrable' in this context refers to the transference of skills to real-world driving performance. Furthermore, to research the main question, it will be supported with the sub-questions: (1) *Are inexperienced drivers <u>without</u> hazard perception training more likely to be involved in accidents compared to experienced drivers?* (2) *Are trainees with simulator hazard perception able to pass the driving exam on their first attempt?* and (3) *Do drivers <u>without</u> simulator hazard perception training participate in more risky behaviours on the road?* As existing research has found possible effects of outcomes, this study will examine if these hold true for this specific research question and explore the support of the sub-statements.

2. Methods

2.1 Participants

A convenience sample of 1.442 (N = 1.442) was used in this research study (*Age-range* = 16-72, M_{age} = 25, SD_{age} = 6.70, Female = 56%, Male = 35%, Unknown = 9%). Participants were recruited from the database of Green Dino. Additional participants, which consisted of acquaintances of the experimenter, were recruited using the same sampling

method. Participants consisted of former driving trainees from various driving schools who followed lessons on a simulator.

Ultimately, after removing participants without a driver's licence, people who did not sign any informed consent, and participants who did not follow simulator training, a sample of 765 (N = 765) remained (*Age-range* = 17-62 M_{age} =24.9, SD_{age} = 6.10, Female = 60%, Male = 39%, Unknown = 9%).

The mean year of being in possession of a driver's licence was 5 years. Furthermore, of the participants who had licence, 454 followed simulator hazard perception training whereas 311 participants followed simulator training *without* hazard perception training.

Moreover, to include a comparison between inexperienced and experienced drivers, categorised in two groups seperately. A driver is considered experienced when he or she is licenced for 7 years and above (Rijksoverheid, 2021). Therefore, for the characteristic of inexperienced drivers, participants licenced under 84 months (< 7 years) were removed. In contrast, for the characteristic of experienced drivers, solely participants licenced 84 months (> 7 years) or above were included.

2.2 Design

This between-subject study investigated the effect between driving performance (with the outcome variables *Accident involvement*, *First pass driving* exam and *Risky behaviour*) and hazard perception training. To illustrate, this study researched this specific effect of hazard perception training with individuals from two groups: (1) Driving simulator *with* hazard perception (HPT) training and (2) Driving simulator *without* hazard perception training. Consequently, the first group will be referred to as the "HPT" group and the second group will be referred to as the "non-HPT" group. The measurement of the dependent variable driving performance in general consisted of the outcome variables: *Accident involvement* (First and last 12 months of driving), *First Pass Driving Exam* and *Risky behaviour*

2.3 Procedure

Each respondent received an email with information about the study (See Appendix A). This email consisted of the goal of the study, the link to the questionnaire and contact details of the experimenters (The sending process of the emails was distributed over multiple emails, as *Microsoft Outlook*, the used mail system in this case, could not exceed 300 email addresses). In essence, 11.700 emails were sent out and in the end a total of 1.442 respondents filled in the questionnaire. Additionally, the email emphasised to the respondent that they were given the possibility to refrain from the study. If they wanted their email to be removed from the database, they could send an email to the company owner of *Green Dino*

that collaborated with the experimenter. When the respondent clicked on the questionnaire link, they were directed to the *Qualtrics* page which presented the respondents with a consent form. If the respondent gave consent, they got directed to the questionnaire where they could start with the questions. The duration of the questionnaire was approximately 10 minutes. Furthermore, the participants were asked if they were interested to receive a summary of the study or if they wanted to participate in the draw for winning 25 x 2 cinema coupons. After completing the questions, the participants were given the possibility to give feedback to the experimenter about the study or general feedback about simulator training.

2.5 Materials

Survey Study

For data acquisition, a questionnaire was developed and displayed in the online program *Qualtrics* (See Appendix A). Because the participants consisted mostly of Dutch driving trainees, the language of the questions were given in Dutch. To complete the questionnaire, the participants needed a working computer or smartphone that could administer the program *Qualtrics*. Moreover, the questionnaire was taken from a study from 2015 and adjusted to this specific research accordingly (Kuipers, n.d). The questions were about driving behaviour (distraction during driving and km driven), simulator experience, type of driving training (hazard perception) and accident involvement. The answers to the questions were coded to facilitate the analysing process. For the variable Risky Behaviour, the sum of the variables: *Phone use, Driving through red light, Driving too fast, Emergency brake use, No priority, Off Road, Alcohol use, Drug use and Not wearing of seatbelt in the first and last 12 months* were taken together for first 12 months and last 12 months. Ultimately from this, the variables *SumRiskyBehaviourFirst12* and *SumRiskyBehaviourLast12* were created.

Simulator Set-up with HPT

The respondents followed a simulator HPT training from Green Dino. The simulator was equipped with automatic feedback in the form of assessment and instruction through the main screen (See Figure 2). Simulator trainees were advised not to have any driving instructors present during the sessions to prevent them from influencing the performance of the trainees. Moreover, the curriculum on the simulator consisted of four modules that were 30 minutes per one or two blocks (Kuipers, n.d). These modules consisted of the *Vehicle Module (Basic vehicle control, the Crossing Module (Crossing intersections), the Highway module (Speed control & Overtaking) and the Specials Module (Eco-driving and Reaction time).*

Figure 2

Set up Simulator for Driving Trainees (Kuipers & Wieringa, 2018)

2.6 Data Analysis

Data analysis was performed with the statistical program *Rstudio* (See Appendix B). Firstly, the dataset was prepared and cleaned in SPSS (Assisted by *Green Dino*). Additionally, the variable of months licenced was changed and transformed. This was done because the values of the variable had words in them, so deemed not suitable for analysis. Furthermore, variables were transformed from character into numerical variables and names were changed to enable clarity. Moreover, a dummy variable *FirstPassExam (*From *Attempts Drivingexam)* was created, which measures the number of individuals with HPT that completed the driving exam in one attempt. Lastly, the total scores of risky behaviour first 12 and last 12 months were calculated *(SumRiskyBFirst12 and SumRiskyBLast12)*.

There were different analyses used for the separate research questions with corresponding outcome variables:

(1) ***Are inexperienced drivers without hazard perception training more likely to be involved in accidents?*** **(**Outcome variable: ***Accident Involvement in first and last year*****)**

To analyse the results of the outcome variable *accident involvement*, descriptive statistics (Means, standard deviations and minimums and maximums) were extracted to determine the differences between the groups (HPT and non-HPT). Furthermore, Inferential statistics were used to analyse this specific effect. As *accident involvement* is a binary variable with answer possibilities yes (1) and no (0), logistic regression was used to analyse differences in probability. Firstly, possible violations of assumptions that applied to this analysis were checked. Consequently, *Nagelkerke's R square* (R^2_N), a measure of goodness of fit in logistic regression analysis, was calculated to determine the effect size.

(2) ***Are trainees with simulator hazard perception able to pass the driving exam on their first attempt?*** **(**Outcome variable: ***First Pass driving exam*****)**

Secondly, to analyse the results of the outcome variable *first pass driving exam*, descriptive statistics (Means, standard deviations and minimums and maximums) were extracted to determine the differences between the groups (HPT and non-HPT). Furthermore, inferential statistics were used to analyse this variable. Similary, like accident involvement, first pass driving exam was a dummy variable with answer possibilities yes (1) and no (0). Therefore, logistic regression was used to analyse differences in probability. Essentially, possible violations of assumptions that applied to this analysis were checked. Ultimately, *Nagelkerke's R square (R^2_N),* a measure of goodness of fit in logistic regression analysis, was calculated to determine the effect size.

(***3) Do Drivers <u>without</u> simulator hazard perception training participate in more risky behaviours on the road?*** **(**Outcome variable: ***Risky Behaviour in first and last year*****)**

Lastly, for the outcome variable *risky behaviour*, descriptive statistics (Means, standard deviations and minimums and maximums) were extracted from the sum of the two risky behaviour groups (First and last year) to determine the differences between the groups (HPT and non-HPT). In contrast, as risky behaviour is a continuous variable, multiple regression was used. To determine the effect size, R^2 was applied. Moreover, for risky behaviour in the last year, the variables km driven and months license were accounted for as they could possibly influence the outcomes. Additionally, this made it possible to see if the results were solely caused by the hazard perception training. Lastly, correlations were calculated between the sum of *Risky Behaviour First 12 Months* and the sum of *Risky Behaviour Last 12 Months* to determine the degree of the relationship between the two.

3. Results

3.1 General Driving Performance Characteristics

Table 1 depicts the general characteristics of participants in terms of driving performance divided into people who received hazard perception training (HPT) or not (Non-HPT) (*Km driven, On Road Training Hours, Driving Exam* and *License)*. The filters that were used in this analysis were: setting the hazard perception score on yes (1) or no (0) for analysing the specific groups separately, km driven first 12 months >= 12 and km driven last 12 months >= 24. Consequently, descriptive statistics were calculated (Means, standard deviations and minimal/maximals). Descriptive statistics carefully suggest that drivers without hazard perception training have more on-road training hours, as the average on road training hours for the non-HPT group is higher. Additionally, the average km driven in the first year is lower for the non-HPT group.

Table 1

Descriptive Statistics General Driving Performance Characteristics Categorised in HPT and No HPT Training

	Hazard Perception Training (*n*=441)				**No Hazard Perception Training (*n*=311)**			
	M	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*
1. Age	24.8	5.76	17	53	25.2	6.55	17	62
2. KmFirst12Months	4881	9849	30	100000	4141	6036	10	35000
3. KmLast12Months	10505	24267	1	360000	10665	22527	10	250000
4. On Road Training hours	41.9	42.5	12	840	43.9	47.9	15	800
5. Driving exam attempts	1.54	.860	0	6	1.51	.836	0	7
6. Licence months	56.2	41.4	12	176	59.9	46.7	12	184

Note. ***Driving exam =*** *Attempts before obtaining license.* ***License*** *= Months,* ***Onroadtraining*** *= hours*

3.2 Accident Involvement

Table 2 depicts the descriptive statistics of the outcome variable *accident involvement* categorised in HPT group and non-HPT group. The filters that were applied in this analysis were: setting the hazard perception score on yes (1) or no (0), simulator = 1 (yes), months licenced first 12 months >= 12, months licenced last 12 months >= 24. Furthermore, to measure the average difference between inexperienced drivers and experienced drivers, they were categorised in two groups separately (Inexperienced drivers < 84 months licenced and Experienced drivers => 84 months licenced).

The overall average score of accidents in the last year is higher for the non-hazard perception group. Furthermore, results show that the average accident involvement in the first year is higher for individuals in the no hazard perception group, which advocates the statement that hazard perception is effective in decreasing accidents in the first year.

Table 2

Descriptive Statistics Accident Involvement Categorised in HP and No HP Training

	Hazard Perception Training (n = 441)			No Hazard Perception Training (*n* = 311)		
	M	*SD*	*n*	*M*	*SD*	*n*
Age First 12 Months	24.8	5.71	-	25.9	3.90	-
Age Last 12 Months	28.4	7.39	-	26.2	3.58	-
Accidents First 12	.070	.256	16	.113	.318	22
Accidents Last 12	.073	.260	21	.085	.280	14
Accidents Inexperienced Last 12	.081	.273	-	.051	.220	-
Accidents Experienced Last 12	.100	.304	-	.104	.307	

Note. ***Accidents First and Last 12*** = First or Last 12 months. ***Accident Inexperienced (of First and last 12 months)*** = < 84 months licenced. *Accidents Experienced (First and last 12 months)* = >= 84 months licenced.

Moreover, logistic regression analysis was used to examine the relationship between hazard perception and *accident involvement in the first* year with taking kilometres driven into account. The filters used in this analysis were: Km driven in the first 12 months > 0, months licenced >= 12, simulator = 1 (yes).

Furthermore, assumptions for logistic regression were checked and were not violated, which enabled the proceedings of the analysis. Table 3 shows the results of the logistic regression and indicates a non-significant effect of hazard perception on accident involvement in the first year As $p > .05$, there is no evidence to suggest any difference in the log odds of accident involvement between the HP and non-HP group, meaning that none of the training groups is more likely to be involved in an accident. However, as the p-value is close to significance, it indicates interest in the effect size and confidence intervals. Subsequently, the goodness of fit measure *Nagelkerke's* R square, showed a weak relationship between hazard perception and accident involvement in first year (R^2_N (538) = .035, p < .001).

Table 3

Logistic Regression for Accident Involvement First 12 Months with Hazard Perception as Predictor Controlling for Kilometres Driven

	Logistic Regression (*n* = 538)				
	b	*SE*	*z*	*p-value*	*CI (95%)*
1. Intercept	-2.23	.230	-9.68	< .001	[-2.70e+0: -1.80e+0]
2. Hazard Perception	-.56	.314	-1.77	.077	[-1.18e+0: 6.21e-2]
3. KM Driven	3.14e-5	1.24e-5	2.49	.001	[6.27e-6: 5.74e-5]

In addition to accident involvement in the first year, logistic regression analysis was used to examine the effect of hazard perception training on *accident involvement in the last year* (Table 4). The variables kilometers driven in the first year and licence were added as extra predictors in addition to hazard perception to see if these have influence on the individual differences. The filters applied to this analysis were: Km driven in the last 12 months > 0, months licenced >= 24 and simulator = 1 (yes).

Additionally, assumptions were checked for logistic regression and indicated that they were not violated. Ultimately, there was no significant effect found between hazard perception and accident involvement in the last 12 months Because $p > .05$, one cannot suggest a difference of accident involvement in the last 12 months between the HP group and the non-HP group. Additionally, *Nagelkerke's R square* revealed a weak relationship between hazard perception and accident involvement in the last (R^2_N (761) = .0001, $p < .001$).

Table 4

Logistic Regression for Accident Involvement Last 12 Months with Hazard Perception as Predictor Controlling for KM driven and Licence

	Logistic Regression (*n*=480)				
	b	*SE*	*z*	*p-value*	*CI (95%)*
1. Intercept	-3.10	.535	-5.80	<.001	[-4.19e+0: -2.08e+0]
2. Hazard Perception	-.03	.348	-.09	.930	[-7.07e-1: 6.67e-1]
3. KM Driven	2.82e-6	6.09e-6	.46	.644	[-1.50e-5; 1.25e-5]
4. Licence	.01	.005	1.58	.113	[-2.05e-3: 1.69e-2]

3.3 First Pass Driving Exam

Logistic regression analysis was used to analyse the relationship between hazard perception and *passing first time of driving exam* (Table 5). Consequently, the filter used in this analysis was: simulator > 0.

Furthermore, assumptions were checked for logistic regression and showed no violation. There was no significant effect found between hazard perception and passing for the first time In essence, as $p > .05$, there is no evidence to suggest a difference in passing first time for driving exam between HP and non HP group. Furthermore, *Nagelkerke's R square* was applied to determine the effect size. This showed a weak relationship between hazard perception and passing the first time for the driving exam (R^2_N (761) = .0001, p < .001).

Table 5

Logistic Regression for First Pass Driving with Hazard Perception as Predictor

	Logistic Regression (*n*=761)				
	b	*SE*	*z*	*p-value*	*CI (95%)*
Intercept	.48	.117	4.10	<.001	[0.252: 0.709]
Hazard Perception	.04	.152	.26	.795	[-0.259: 0.337]

3.4 Risky Behaviour

Descriptives were extracted for the sum of *risky behaviours* per participant (The sum of the variables *Phone use, Driving through red light, Driving too fast, Emergency brake use, No priority, Off Road, Alcohol use, Drug use and Not wearing of seatbelt)* for the first 12 and last 12 months (See Table 6). Higher scores are interpreted as indicator of riskier driving behavior. Descriptive statistics indicate that the average score of risky behaviours in the last year is higher for the HP group than the average score in the non-HP group.

Table 6

Descriptive Statistics Risky Behaviours First and Last 12 Months

	Hazard Perception Training				**No Hazard Perception Training**			
	M	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*
Risky Behaviours First 12	3.84	2.88	0	21	3.41	2.33	0	15

Risky Behaviours Last 12	4.26	3.43	0	21	4.15	3.17	0	12

Note. ***Risky Behaviours*** = Sum of variables Phone use, Driving through red light, Driving too fast, Emergency brake use, No priority, Off Road, Alcohol use, Drug use and Not wearing of seatbelt.

Table 7

Regression Analysis for Risky Behaviours First 12 Months with Hazard Perception as Predictor Controlling for KM driven

	Regression Analysis (*n* = 538)				
	b	*SE*	*t*	*p-value*	*CI (95%)*
1. Intercept	3.19	.202	15.8	<.001	[-2.79e+0: 3.59]
2. Hazard Perception	.384	.248	1.55	.121	[-1.02e-1:.871]
3. KM Driven	5.29e-5	1.36e-5	3.89	<.001	[2.62e-5: 0.0000796]

Furthermore, multiple regression analysis was used to examine the effect of hazard perception on the *risky behaviour in the first 12 months* (see Table 7). The variable kilometers driven in the first 12 months was included as second predictor, to control for the individual differences in number of kilometres driven. The filters applied to this analysis were: km driven first year > 0, months licenced >= 12 .

Furthermore, assumptions for linear regression were checked (Normality, Linearity and Homoscedasticity) and were not violated. As seen in Table 7, hazard perception does not have a significant effect on risky behaviour in the first 12 months. Consequently, 3.64% of the variation in risky behaviours in the first year can be explained by hazard perception (R^2 = .036, p <.001).

Table 8

Regression Analysis for Risky Behaviours Last 12 Months with Hazard Perception as Predictor Controlling for KM driven and Licence

	Regression Analysis (*n* = 480)				
	b	*SE*	*t*	*p-value*	*CI (95%)*
1. Intercept	3.96	.486	8.14	<.001	[2.94e+0: 4.83]

2. Hazard Perception	-0.0347	.322	-.108	.914	[-6.26e-1: 0.632]
3. KM Driven	3.24e-5	6.00e-6	4.91	<.001	[1.93e-5: 0.0000451]
4. Licence	0.000778	0.00473	.165	.869	[-7.97e-3: 0.0105]

Similarly, to measure the effect of hazard perception on the *risky behaviour in the last 12* months, multiple regression analysis was used (see Table 8). Moreover, the kilometers driven in the last 12 months and licence were included as extra predictors. The filters applied to this analysis were: Km driven 12 months > 0, months licenced >= 24 and simulator = 1 (yes).

Furthermore, assumptions for linear regression were checked and were not violated. As seen in Table 6, hazard perception does not have a significant effect on risky behaviour in the first 12 months. 5.00% of variation in risky behaviours in the last year can be explained by hazard perception (R^2 = .050, p < .001).

Consequently, correlations were calculated for the total sum of risky behaviours for the first 12 months and for the last 12 months (behaviours used were *Phone use, Driving through red light, Driving too fast, Emergency brake use, No priority, Off Road, Alcohol use, Drug use and Not wearing of seatbelt*). Ultimately, a strong correlation was found between the sum of risky behaviours in the first year and the sum of risky behaviours in the last year (r(469) = .647, p < .001). This indicates that individuals engage in the same risky behaviours in their last year compared to their first year.

4. Discussion

This exploratory survey study investigated the effectiveness of simulator hazard perception training on driving performance. Notably, the aim of this research was to provide more insight into the importance of hazard perception training and driving performance, specifically concerning the aspect of decreasing road fatalities among drivers. The corresponding research question was: *does hazard perception training with driving simulators have transferrable effects on driving performance in the real-world?* To support the main research question, three sub-statements were developed. It was expected that: (1) *Inexperienced drivers without hazard perception training are more likely to be involved in accidents,* (2) *Trainees with simulator hazard perception able to pass the driving exam in*

their first attempt and (3) *Drivers without simulator hazard perception training participate in more risky behaviours on the road*. In essence, taking the hazard perception training did not reveal a predictive significant effect on the measured outcome variables, namely *Accident Involvement, First Pass Exam* and *Risky Behaviour.* The following sections will highlight the results and corresponding explanations, limitations of the study, and future recommendations for replication.

To examine the average differences of the general driving characteristics (Km driven, on-road training hours and months licenced), descriptive statistics were calculated for both the hazard perception group and the group without hazard perception. In essence, descriptive statistics reveal that there are differences between the two groups. To illustrate, although no further statistical tests were performed, the average score on road training hours was higher for the participants in the hazard perception group compared to the participants who did not follow hazard perception training. According to Horswill (2016), acquiring hazard perception skills is a difficult ability for individuals who do not have any driving experience and do not train these skills regularly. Therefore, driving trainees would need supplementary on road hours to train these skills. Thus, it was expected that the on-road training for participants without any additional hazard perception training would be higher than with hazard perception training. Ultimately, these results are in line with research of Horswill (2016) and Kuipers & Wieringa (2018), which indicate that drivers without regular training of hazard perception skills probably require more hours to acquire sufficient anticipation skills to detect hazards on the road.

Secondly, to investigate the effect of hazard perception on outcome variable accident involvement in the first and last year, descriptive statistics and logistic regression analyses were used. Additionally, differences between inexperienced and experienced drivers were considered. Results show a non-significant effect of hazard perception on accident involvement in the first and last year. Solely, the difference of accident involvement in the first year approaches significance. Additionally, there was a negative estimate value for the both HPT and non-HPT groups in the first year. This could indicate that if HPT would be applied, that the number of accidents in this group would decrease. Therefore, it deems relevant to research this effect again with a different method and taking the causes of accidents into account, as these were measured but not used in this research. Expectedly, descriptives showed that hazard perception training possibly decreases accident involvement in the first year and thus one can carefully indicate that inexperienced drivers without hazard perception are relatively more involved in accidents. This is in line with Vlakveld (2013) and

Mcknight & Mcknight (2003), which assert that inexperienced drivers are more prone to errors due to poor visual scanning skills and underdeveloped information processing skills and are ultimately more involved in accidents. However, one can carefully suggest that in contrast to inexperienced drivers, experienced drivers are on average more involved in accidents in their last year of driving. This result can be explained by overestimation and overconfidence driving skills. Correspondingly, Vlakveld (2008) argues that determining the load of a task is person dependent. For example, in the context of driving, an experienced driver is more capable to take risks, which in turn increases the workload of driving (Reduced space in working memory) as they will drive faster.

Furthermore, the variable first pass of driving exam was analysed. This measured the number of individuals who passed their driving exam in first time. This was done with logistic regression analysis. It was expected that driving trainees in the hazard perception group would have higher passing rates (Kuipers, n.d). In similar vein, Kuipers & Wieringa (2018) contend that hazard perception training with FOV increases the chance that trainees perform better on their first driving exam. However, results of this research do not support this finding. Logistic regression analysis shows a non-significant effect of hazard perception training on the passing of the driving exam in first time. Moreover, descriptives were calculated for the driving exam attempts of the HP group and the non-HP group and corresponded with the non-significant finding, as the average attempts of driving exam for the non-HP group was not higher compared to the participants in the HP group, which indicates that trainees without HP training do not necessarily need more attempts for their driving exam. Hence, a possible cause of this non-significant effect could be the phrasing of the question regarding this specific question, which could have caused difficulties with understanding. The participants had to indicate how many times they had to do the driving exam *before* passing it. As a result, participants could have mixed up the numbers.

Lastly, multiple regression analysis was used to analyse the effect of hazard perception on risky behaviour in the first and last 12 months of driving. To increase internal validity, ensure that external variables do not influence the effect of HPT on individual differences, the variables Kmdriven and Licence (Only for last year), were controlled for in the model. For both risky behaviour in the first and last year, the total score was calculated from the different risky behaviours that were included in the questions of the questionnaire. Additionally, descriptive statistics were calculated to determine the average differences between risky behaviour in the HP group and the non-HP group. It was expected that drivers with hazard perception training are more risk averse while driving. Ultimately, results do not support this

notion. The average score of risky behaviour in the first and last year was higher for the HP group, which suggests that they take more risks. However, multiple regression analyses revealed non-significant effects for risky behaviour in both the first and last year of driving and showed that neither of the groups demonstrates riskier driving behaviour than the other. Notably, these results can be explained by the *illusion of knowledge.* The illusion of knowledge entails that when one has mastered sufficient abilities or knowledge, he or she overestimates their ability to do something (Hall et al.,2007). As a result, they are more eager to underestimate their hazard perception skills in a hazardous situation. Hence, this could imply that drivers take more risks with a hazard perception training, as they see this training as extra knowledge and thus see themselves capable to handle risks better.

Consequently**,** there were some limitations that possibly caused the non-significant effects of hazard perception training on the various outcome variables. One imperative limitation is that this research was based on *self-reported data*. As the study used subjective answers of a questionnaire to research the effect of hazard perception, the outcomes can be regarded as biased. According to Chan (2008), by using self-reported measures, validity of data can be reduced and therefore considered as biased. Furthermore, this study was a longitudinal study over period of more than 5 years. As a result, multiple participants were not able to recall their exact number of kilometers or the exact number of attempts of driver's exam. This could have possibly influenced the validity of the results. Lastly, the questions that measured the outcome variable first pass driving exam were not phrased correctly, with as result that participants could have answered wrong number of driving exam attempts.

There are several recommendations for future research to examine the effectiveness of simulator hazard perception training on driving performance. Firstly, to support the self-reported measurement, validity of data can be improved by using real driving data to enable more accuracy of kilometres driven and number of FOV hazard perception training. Additionally, the period between the hazard perception training and the questionnaire should be shorter to enable more accurate recall of the participants. Therefore, the study should consider another direction than a longitudinal study. For example, a repeated measurement study where participants complete a few hazard perception scenario's and then fill in a short questionnaire. Secondly, for replication of this study, participants should follow more simulator training to increase training effects and enable accurate answers of participants. Furthermore, with this curriculum driving trainees receive simulator HPT in the beginning phase of their driving lessons. Therefore, for future research, it would be beneficial to see what effect it would have if HPT is applied right before the driving exam.

Lastly, as driving anxiety is shown to influence hazard perception skills in driving performance, it is imperative that the effect of simulators on driving anxiety is considered in the future (Nahvi et al., 2022). According to Freitas et al. (2021) simulator driving acts as VRET (*Virtual Reality Exposure Therapy).* As a result, VRET induces a sense of immersion and realism and can decrease driving anxiety. Moreover, VRET therapy lowered driving anxiety and avoidance of female drivers in a period of 7 months (Freitas et al., 2021). Ultimately, when researching the effect of driving anxiety, it can be determined if hazard perception training can indeed result in lower anxiety levels.

Conclusion

In conclusion, this exploratory study did not find any differences to explain the effect of driving simulators on the hazard perception of drivers, which indicates that simulator hazard perception does not seem to lead to better and safe driving performance. Therefore, it is good to consider the possible improvements and suggestions to implement in replicating this study in the future with a positive outlook. As acquiring hazard perception skills and monitoring information processing skills are crucial aspects for drivers, it still deems relevant to research further possibilities of the effects of simulators on making drivers aware of their driving skills to anticipate dangers on the road. This can ultimately, aid in preventing traffic fatalities among (novice) drivers.

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Appendices

Appendix A Email Sent to Participants

Beste oud-rijsimulator leerling,

Je ontvangt deze email omdat dit emailadres in een rijsimulator van Green Dino is ingevoerd, wat betekent dat jij je autorijbewijs hebt behaald bij een rijschool die gebruikt maakt van een rijsimulator van ons. Om het effect van de rijsimulator te bepalen op de rijopleiding en op ongevallen na het behalen van het rijbewijs, hebben wij jouw hulp nodig!

Het onderzoek wordt door mij, Sophie van Keulen, in samenwerking met Green Dino uitgevoerd. Ik ben psychologie studente aan de Universiteit Twente. Wij hebben een vragenlijst opgesteld met een aantal vragen over jouw rijopleiding en jouw rijgedrag na het behalen van je rijbewijs. Met jouw antwoorden kan ik onderzoeken op welke manier de simulator bijdraagt aan een veiliger verkeer. Jouw rijschool is niet betrokken bij dit onderzoek.

Het invullen van de vragenlijst kan op je smartphone of pc en duurt ongeveer 5 tot 10 minuten. De enige voorwaarde voor deelname is dat je in het bezit bent van een rijbewijs. Persoonlijke informatie wordt vertrouwelijk en geanonimiseerd verwerkt en wordt nooit gedeeld met andere partijen.

Onder de deelnemers die de vragenlijst voor 11 mei invullen worden 25 x 2 bioscoopbonnen ter waarde van €25,- verloot. Als je interesse hebt in het onderzoek, kan je aangeven dat je een samenvatting van de resultaten wil ontvangen.

Via deze link kan je de vragenlijst openen: https://utwentebs.eu.qualtrics.com/jfe/form/SV_e9GoAOBH75qvpLU

Alvast bedankt voor je medewerking!

Met vriendelijke groet,
Sophie van Keulen

PS: als je wil dat wij je email adres verwijderen uit de database, of andere vragen hebt, dan kun je contact opnemen met Jorrit Kuipers van Green Dino, j.kuipers@greendino.nl

Appendix B : Questionnaire Study

Questionnaire: Effectiviteit Rijsimulatoren en Gevaarherkenning Bestuurders

Start of Block: Introductie

Q45 Deze studie onderzoekt het effect van de simulator rijlessen op de slagingskans en het rijgedrag na het behalen van het rijbewijs aan de hand van een aantal vragen. Dit onderzoek wordt uitgevoerd door de Psychology afdeling van de Universiteit Twente (Contact informatie onderzoeker: s.m.vankeulen@student.utwente.nl) in samenwerking met Green Dino (fabrikant van de simulator) met als doel het verminderen van ongevallen en het verhogen van de verkeersveiligheid.

Er zijn geen risico's verbonden aan deze studie. Probeer deze vragen zo nauwkeurig en eerlijk mogelijk te beantwoorden, zodat wij een betrouwbaar beeld van de effecten van de simulator kunnen vormen op de verkeersveiligheid.

Toestemmingsverklaring:
Hierbij geef ik toestemming dat mijn antwoorden worden gebruikt om het effect van de rijsimulator te onderzoeken. Ik ben op de hoogte van het doel van de studie en de risico's. Ik weet dat er vertrouwelijk met mijn persoonlijke informatie wordt omgegaan en dat mijn gegevens niet worden gedeeld met andere partijen. Ik ben op de hoogte dat ik elk moment kan stoppen met de studie zonder reden en dat ik extra informatie kan opvragen bij de onderzoeker.

Ik geef toestemming

- ○ Ja (1)
- ○ Nee (0)

Skip To: End of Survey If Deze studie onderzoekt het effect van de simulator rijlessen op de slagingskans en het rijgedrag... = Nee

Q75 Ik wil graag een samenvatting van de resultaten ontvangen

- Nee (0)
- Ja, op dit e-mailadres (1) _____

End of Block: Introductie

Start of Block: Demographics

Q1 Wat is je huidige leeftijd?

_____

Q2 Wat is je geslacht?

- Man (1)
- Vrouw (2)
- Anders (3) _____
- Wil ik liever niet zeggen (0)

Q3 Wat is je huidige opleidingsniveau? Als je niet met een opleiding bezig bent, kruis dan aan wat je hoogst behaalde opleiding is

- ○ Basisonderwijs (1)
- ○ Praktijkonderwijs (2)
- ○ VMBO (3)
- ○ HAVO (4)
- ○ VWO (5)
- ○ MBO (6)
- ○ HBO (7)
- ○ WO (8)

X→ X→

Q4 Iedereen heeft een eigen manier van leren. Hierin zijn 3 verschillende types te onderscheiden:

1. Ik wil graag de theorie goed beheersen voor ik iets in de praktijk doe. Ik denk goed na voor ik een beslissing neem en neem hier graag de tijd voor. Ik ben voorzichtig, ik maak niet graag fouten. Ik begrijp iets/denk liever eerst na voordat ik iets doe.

2. Ik vind het leuk om dingen uit te proberen, en een verband te vinden tussen theorie en praktijk. Van fouten maken leer ik het meest. Ik vind fouten maken niet erg, want van fouten leer je. Maar ik heb wel graag een plan voordat ik begin.

3. Nieuwe ervaringen opdoen is voor mij belangrijk. Ik hoef niet precies de theorie achter dingen te weten en wil niet te veel nadenken, maar gewoon doen. Ik ga het liefst gelijk aan de slag en probeer verschillende manieren uit zodat ik op zoek kan gaan naar de beste manier. Ik leer door te doen, zonder fouten maken kan je bovendien niet leren.

Welke van deze 3 manieren past het best bij jou?

- ○ Manier 1 (1)
- ○ Manier 2 (2)
- ○ Manier 3 (3)

End of Block: Demographics

Start of Block: Algemeen

Q6 Ben je in het bezit van een rijbewijs?

- Ja (1)
- Nee (0)

Skip To: End of Survey If Ben je in het bezit van een rijbewijs? = Nee

Page Break

Q12 Wanneer heb je je rijbewijs gehaald (Dag/Maand/Jaar)? Je kan deze informatie vinden achterop je rijbewijs.

_____

Page Break

Q44 Heb je tijdens je rijopleiding simulator lessen gevolgd?

- ○ Ja (1)
- ○ Nee (0)

Skip To: Q7 If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Nee

Q46 Bij je rijschool is er een e-mailadres doorgegeven waarmee jij bekend bent in de simulator. Als het goed is, is dit het adres waarop je ook de link naar deze vragenlijst hebt ontvangen. Met dit adres kunnen we zien welk type simulator lessen je hebt gevolgd. Deze simulator gegevens kunnen aan de hand van jouw e-mailadres dan gekoppeld worden aan de antwoorden op deze vragenlijst. Wij waarderen jouw privacy, dus je email adres wordt verwijderd na gebruik voor dit onderzoek.

Vul hier het besproken e-mailadres in

_____

X→ X→

Q43 Heb je tijdens je rijopleiding gevaarherkenning training gehad op de simulator? (Dit is een specifieke les)

- ○ Ja (1)
- ○ Nee (0)

Page Break

X→ X→

Q7 Heb je je rijbewijs via 2toDrive gehaald? (Bij 2toDrive haal je je rijbewijs voor je 18e en rijdt je onder begeleiding tot je 18 bent)

- ○ Ja (1)
- ○ Nee (0)

Skip To: Q9 If Heb je je rijbewijs via 2toDrive gehaald? (Bij 2toDrive haal je je rijbewijs voor je 18e en rijdt... = Nee

Q8 Je hebt aangegeven dat je je rijbewijs via 2toDrive hebt gehaald. Hoe vaak heb je voor je 18e onder begeleiding autogereden?

- Nooit (0)
- Zelden (Minder dan 1 keer per maand) (1)
- Soms (Ongeveer 1 keer per maand) (2)
- Regelmatig (Ongeveer 1 keer per week) (3)
- Zeer regelmatig (Meerdere keren per week) (4)
- Vrijwel elke dag (5)

Page Break

Q9 Hoeveel hele uren (60 minuten) heb je praktijkles gehad? Het gaat hier om de lessen die je van je rij-instructeur op de weg hebt gehad (eventuele simulator lessen tellen niet mee).

_____

Q10 Wist je je antwoord op de vorige vraag zeker of was dit een grove schatting?

- Zeker (1)
- Schatting (0)

Q52 Wat heb je betaald voor een rijles van 1 uur?

0 10 20 30 40 50 60 70 80 90 100

Euro ()

Q56 Hoeveel euro vind jij een rijles op de weg waard?

0 10 20 30 40 50 60 70 80 90 100

Euro ()	

Q57 Hoeveel euro vind jij een simulator rijles waard?

0 10 20 30 40 50 60 70 80 90 100

Euro ()	

Page Break

Q11 Hoe vaak heb je het praktijkexamen afgelegd voor je je rijbewijs haalde?

_____

Q37 Vond je het eng om auto te rijden toen je begon met je rijopleiding?

- Helemaal niet (0)
- Nauwlijks (1)
- Een beetje (2)
- Redelijk (3)
- Heel erg (4)

Page Break

End of Block: Algemeen

Start of Block: Rijgedrag

Q60 Ik vind dat ik beter kan autorijden dan andere bestuurders.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)

Q65 Ik vind autorijden soms lastig.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)

Page Break

Q13 De volgende vragen gaan over jouw gedrag in het verkeer, in de **eerste 12 maanden na het halen van je rijbewijs.** Geef bij elke vraag aan hoe vaak je het betreffende gedrag vertoonde. Deze vragen dienen puur om een beeld te krijgen van automobilisten in het algemeen; er zitten voor jou persoonlijk geen consequenties aan vast. Het is belangrijk dat je eerlijk antwoord geeft.

Q14 Hoeveel kilometer heb je in de eerste 12 maanden na het halen van je rijbewijs (ongeveer) gereden? (Denk hierbij aan wekelijkse ritten, maar ook aan vakanties of dagjes weg)

_____

Q49 Is dit een grove schatting of nauwkeurig?

- Grove schatting (1)
- Vrij nauwkeurig (2)
- Zeer nauwkeurig (3)
- Ik weet het niet (4)

Q15 Onder ongeluk wordt verstaan: een botsing met iets of iemand op een openbare weg met schade als gevolg. Het maakt niet uit hoe ernstig het ongeval was, of wiens schuld het was.

Ben je bij een ongeluk betrokken geweest in de eerste 12 maanden na het halen van je rijbewijs?

- Ja (1)
- Nee (0)

Skip To: Q18 If Onder ongeluk wordt verstaan: een botsing met iets of iemand op een openbare weg met schade als g... = Nee

Q16 Bij hoeveel ongelukken ben je betrokken geweest in de eerste 12 maanden?

- 1 (1)
- 2 (2)
- 3 (3)
- Meer dan 3 (4)

Q50 Bij hoeveel van deze ongevallen was jij de schuldige?

- ○ 0 (0)
- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ Meer dan 3 (4)
- ○ Wil ik niet zeggen (5)

Q51 Bij hoeveel van deze ongevallen was jij de enige betrokken bestuurder (eenzijdig ongeval). Het gaat hier om een ongeval waarbij jij de enige verkeersdeelnemer was, bijvoorbeeld parkeerschade of het raken van een obstakel in de berm.

- ○ 0 (1)
- ○ 1 (2)
- ○ 2 (3)
- ○ 3 (4)
- ○ Meer dan 3 (5)

Q17 Bij hoeveel ongelukken waar je in de eerste 12 maanden bij betrokken was, moest er iemand in het ziekenhuis worden behandeld?

- ○ 0 (1)
- ○ 1 (2)
- ○ 2 (3)
- ○ 3 (4)
- ○ Meer dan 3 (5)

Page Break

Q18 Kruis bij de komende vragen alleen de optie “Kan ik me niet meer herinneren” aan als je echt geen schatting kan geven.

Hoe vaak kwam het in de eerste 12 maanden voor dat je meer dan 10 kilometer per uur te hard reed binnen de bebouwde kom?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q19 Hoe vaak kwam het in de eerste 12 maanden voor dat je tijdens het rijden een bericht las/verstuurde op je mobiele telefoon?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q20 Hoe vaak kwam het in de eerste 12 maanden voor dat je (bewust) door rood licht reed?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q22 Hoe vaak kwam het in de eerste 12 maanden voor dat je een noodstop moest maken omdat je dicht op de auto voor je reed?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q24 Hoe vaak kwam het in de eerste 12 maanden voor dat je een of meer glazen alcoholhoudende drank op had wanneer je ging rijden?

- ○ Nooit (0)
- ○ Zelden (minder dan 1 keer per maand) (1)
- ○ Soms (ongeveer 1 keer per maand) (2)
- ○ Regelmatig (ongeveer 1 keer per week) (3)
- ○ Zeer regelmatig (meerdere keren per week) (4)
- ○ Bijna elke autorit (5)
- ○ Kan ik me niet herinneren (6)

X→ X→

Q25 Hoe vaak kwam het in de eerste 12 maanden voor dat je bent gaan rijden terwijl je onder de invloed was van drugs? (Lachgas wordt hier ook bij bedoeld)

- ○ Nooit (0)
- ○ Zelden (minder dan 1 keer per maand) (1)
- ○ Soms (ongeveer 1 keer per maand) (2)
- ○ Regelmatig (ongeveer 1 keer per week) (3)
- ○ Zeer regelmatig (meerdere keren per week) (4)
- ○ Bijna elke autorit (5)
- ○ Kan ik me niet herinneren (6)

X→ X→

Q26 Hoe vaak kwam het de eerste 12 maanden voor dat jij zonder gordel reed?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q27 Hoe vaak kwam het de eerste 12 maanden voor dat je van de weg raakte en bijvoorbeeld in de berm, tegen de stoep, of op de verkeerde rijstrook terecht kwam?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q29 Hoe vaak kwam het de eerste 12 maanden voor dat je geen voorrang verleende waar dit wel zou moeten?

- ○ Nooit (0)
- ○ Zelden (minder dan 1 keer per maand) (1)
- ○ Soms (ongeveer 1 keer per maand) (2)
- ○ Regelmatig (ongeveer 1 keer per week) (3)
- ○ Zeer regelmatig (meerdere keren per week) (4)
- ○ Bijna elke autorit (5)
- ○ Kan ik me niet herinneren (6)

Page Break

Q36 De volgende vragen gaan over jouw rijgedrag in de **laatste 12 maanden.** Geef bij elke vraag aan hoe vaak je het betreffende gedrag vertoonde. Deze vragen dienen puur om een beeld te krijgen van automobilisten in het algemeen; er zitten voor jou persoonlijk geen consequenties aan vast. Het is belangrijk dat je eerlijk antwoord geeft.

Hoeveel kilometer heb je in de afgelopen 12 maanden ongeveer gereden? Denk hierbij aan wekelijkse ritten, maar ook aan vakanties of dagjes weg.

_____

X→ X→

Q76 Is dit een grove schatting of nauwkeurig?

- ○ Grove schatting (0)
- ○ Vrij nauwkeurig (1)
- ○ Zeer nauwkeurig (2)
- ○ Ik weet het niet (3)

X→ X→

Q30 Onder ongeval wordt verstaan: een botsing met iets of iemand op een openbare weg met schade als gevolg. Het maakt niet uit hoe ernstig het ongeval was, of wiens schuld het was.

Ben je de afgelopen 12 maanden betrokken geweest bij een ongeval?

- Ja (1)
- Nee (0)

Skip To: Q66 If Onder ongeval wordt verstaan: een botsing met iets of iemand op een openbare weg met schade als g... = Nee

X→ X→

Q31 Hoe vaak ben je de afgelopen 12 maanden betrokken geweest bij een ongeval?

- 1 (1)
- 2 (2)
- 3 (3)
- Meer dan 3 (4)

X→ X→

Q58 Bij hoeveel van deze ongevallen was jij de schuldige?

- 0 (0)
- 1 (1)
- 2 (2)
- 3 (3)
- Meer dan 3 (4)
- Wil ik niet zeggen (5)

Q59 Bij hoeveel van deze ongevallen was jij de enige betrokken bestuurder (eenzijdig ongeval). Het gaat hier om een ongeval waarbij jij de enige verkeersdeelnemer was, bijvoorbeeld parkeerschade of het raken van een obstakel in de berm.

- 0 (0)
- 1 (1)
- 2 (2)
- 3 (3)
- Meer dan 3 (4)

Q35 Hoe vaak moest iemand in het ziekenhuis worden behandeld als gevolg van een ongeluk waar jij betrokken bij was (in de afgelopen 12 maanden)?

- 0 (0)
- 1 (1)
- 2 (2)
- 3 (3)
- Meer dan 3 (4)

Page Break

Q66 Kruis bij de komende vragen alleen de optie “Kan ik me niet meer herinneren” aan als je echt geen schatting kan geven.

Hoe vaak kwam het in de laatste 12 maanden voor dat je meer dan 10 kilometer per uur te hard reed binnen de bebouwde kom?

- ○ Nooit (0)
- ○ Zelden (minder dan 1 keer per maand) (1)
- ○ Soms (ongeveer 1 keer per maand) (2)
- ○ Regelmatig (ongeveer 1 keer per week) (3)
- ○ Zeer regelmatig (meerdere keren per week) (4)
- ○ Bijna elke autorit (5)
- ○ Kan ik me niet herinneren (6)

X→ X→

Q67 Hoe vaak kwam het in de laatste 12 maanden voor dat je tijdens het rijden een bericht las/verstuurde op je mobiele telefoon?

- ○ Nooit (0)
- ○ Zelden (minder dan 1 keer per maand) (1)
- ○ Soms (ongeveer 1 keer per maand) (2)
- ○ Regelmatig (ongeveer 1 keer per week) (3)
- ○ Zeer regelmatig (meerdere keren per week) (4)
- ○ Bijna elke autorit (5)
- ○ Kan ik me niet herinneren (6)

X→ X→

Q68 Hoe vaak kwam het in de laatste 12 maanden voor dat je (bewust) door rood licht reed?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q69 Hoe vaak kwam het in de laatste 12 maanden voor dat je een noodstop moest maken omdat je dicht op de auto voor je reed?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q70 Hoe vaak kwam het in de laatste 12 maanden voor dat je een of meer glazen alcoholhoudende drank op had wanneer je ging rijden?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q71 Hoe vaak kwam het in de laatste 12 maanden voor dat je bent gaan rijden terwijl je onder de invloed was van drugs? (Lachgas wordt hier ook bij bedoeld)

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q72 Hoe vaak kwam het de laatste 12 maanden voor dat jij zonder gordel reed?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q73 Hoe vaak kwam het de laatste 12 maanden voor dat je van de weg raakte en bijvoorbeeld in de berm, tegen de stoep, of op de verkeerde rijstrook terecht kwam?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

Q74 Hoe vaak kwam het de laatste 12 maanden voor dat je geen voorrang verleende waar dit wel zou moeten?

- Nooit (0)
- Zelden (minder dan 1 keer per maand) (1)
- Soms (ongeveer 1 keer per maand) (2)
- Regelmatig (ongeveer 1 keer per week) (3)
- Zeer regelmatig (meerdere keren per week) (4)
- Bijna elke autorit (5)
- Kan ik me niet herinneren (6)

End of Block: Rijgedrag

Start of Block: Simulator

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

Q39 De volgende statements gaan over de simulator. We horen graag je mening over de simulator, dus wees niet bang om eerlijk te zijn!

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

Q40 Ik vond het leuk om in de simulator te rijden.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

Q41 De simulatorlessen waren een goede voorbereiding voor de praktijklessen op de weg.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

Q43 De simulatorlessen hebben mij geleerd beter te kijken/anticiperen op kruispunten.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

Q45 Ik zou anderen (bijv. vrienden, familie, kennissen) aanraden om simulatorlessen te volgen.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

Q46 Ik heb het gevoel dat een uur rijles in de simulator een uur rijles op de weg kan vervangen.

- ○ Helemaal oneens (0)
- ○ Oneens (1)
- ○ Neutraal (2)
- ○ Eens (3)
- ○ Helemaal eens (4)

Display This Question:

If Heb je tijdens je rijopleiding simulator lessen gevolgd? = Ja

X→ X→

Q47 Door de simulatorlessen vond ik het minder spannend om in de auto op de weg te rijden.

- ○ Helemaal oneens (0)
- ○ Oneens (1)
- ○ Neutraal (2)
- ○ Eens (3)
- ○ Helemaal eens (4)

Page Break

Display This Question:

If Heb je tijdens je rijopleiding gevaarherkenning training gehad op de simulator? (Dit is een speci... = Ja

Q62 Door de gevaarherkenning training ben ik voorzichtiger gaan rijden.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)
- Ik heb geen gevaarherkenning training gevolgd in de simulator (5)

Display This Question:

If Heb je tijdens je rijopleiding gevaarherkenning training gehad op de simulator? (Dit is een speci... = Ja

Q63 Door de gevaarherkenning training ben ik ... gaan rijden.

- Voorzichtiger (1)
- Bewuster (2)
- Agressiever (3)
- Geen verschil (4)
- Ik heb geen gevaarherkenning training gevolgd in de simulator (5)

Display This Question:

If Heb je tijdens je rijopleiding gevaarherkenning training gehad op de simulator? (Dit is een speci... = Ja

Q64 Door de gevaarherkenning training weet ik beter hoe ik gevaren kan detecteren.

- Helemaal oneens (0)
- Oneens (1)
- Neutraal (2)
- Eens (3)
- Helemaal eens (4)
- Ik heb geen gevaarherkenning training gevolgd in de simulator (5)

End of Block: Simulator

Start of Block: Feedback

Q48 Wil je mee loten voor de 25 x 2 bioscoopbonnen ter waarde van €25?

- Ja (1)
- Nee (0)

Q77 Mocht je nog feedback hebben, kun je dat hieronder aangeven.

_____

_____

_____

_____

_____

End of Block: Feedback

Appendix C Rscript Data Analysis

```
## Dataset

read.csv("Questionnaire_Effectiviteit_Rijsimulatoren_en_Gevaarherkenning_Bestuurders_April_20_2023_01_59.csv")
View(Questionnaire_Effectiviteit_Rijsimulatoren_en_Gevaarherkenning_Bestuurders_April_20_2023_01_59)

Correlations <- SimData %>%
select(Gender,Age,HazardPerception,Maandenrijbewijs,N_DrivingExam,More10KMFirst12:NoVoorrangFirst12, More10KMLast12:NoVoorrangLast12,
                        KM_first12Months,KM_last12Months,
AccidentFirst12,AccidentLast12, OnroadTrainingHours, AnxietyAfterSim, Simulator, AnxietyStartDriving, DifficultyDriving)

RiskyBehaviours <- Correlations %>% select(More10KMFirst12:NoVoorrangFirst12, More10KMLast12:NoVoorrangLast12)

names(SimData) <-
c("Consent","Coupon","Summary","Age","Gender","Different","EducationLevel","Learning Style","DriversLicence","LicenceString","LicenceDataExact",

"Simulator","HazardPerception","2ToDrive","DrivingB418","OnroadTrainingHours","Certainty","PaidDrivinglesson","WorthDrivinglesson","WorthSimlesson",

"N_DrivingExam","AnxietyStartDriving","OverestimationDrivingskills","DifficultyDriving", "KM_first12Months","CertaintyKMFirst12","AccidentFirst12",

"N_AccidentsFirst12","OwnFaultAccidentFirst12","OnlyDriverAccidentFirst12","N_HospitalFirst12","More10KMFirst12","PhoneUseFirst12",

"RedLightFirst12","BrakeFirst12","AlcoholFirst12","DrugsFirst12","NoSeatbeltFirst12","OffRoadFirst12","NoVoorrangFirst12","KM_last12Months",

"CertaintyLast12","AccidentLast12","N_AccidentsLast12","OwnFaultAccidentLast12","OnlyDriverAccidentLast12","N_HospitalLast12","More10KMLast12",

"PhoneUseLast12","RedLightLast12","BrakeLast12","AlcoholLast12","DrugsLast12","NoSeatbeltLast12","OffRoadLast12","NoVoorrangLast12",

"ExperienceSim","PrepRealRoadSim","AnticipateHPSim","ReccomendSim","ReplacementSim","AnxietyAfterSim","CarefulHPSim","DrivingStyleHPSim",
            "BetterHPAfterSim","FeedbackSim","CurrentDate","Maandenrijbewijs")
```

```
## DOWNLOAD LIBRARIES
library(tidyverse)
library(haven)
library(tidyverse)
library(janitor) #for visualising the data
library(broom)
library(dplyr)
library(foreign)
library(moments)
library(ggplot2)
library(fmsb)

#
table(Correlations$Gender, exclude = NULL)



## Filters

Correlations <- Correlations %>% filter(HazardPerception == 0)
Correlations <- Correlations %>% filter(HazardPerception == 1)
Correlations <- Correlations %>% filter(AccidentLast12 == 1)

## Filter Driving exam
Correlations <- Correlations %>% filter(Simulator > 0, OnroadTrainingHours < 1000,
OnroadTrainingHours > 10)
# Filter for HP --> Accident first 12
Correlations <- Correlations %>% filter(Simulator > 0, KM_first12Months > 0
,OnroadTrainingHours > 10, OnroadTrainingHours < 1000 ,Maandenrijbewijs >= 12 )
#Filter Last year
Correlations <- Correlations %>% filter(Simulator > 0, KM_last12Months > 0,
OnroadTrainingHours > 10, OnroadTrainingHours < 1000, Maandenrijbewijs >= 24 )
# Filter INex
Correlations <- Correlations %>% filter(Simulator > 0,KM_last12Months > 0
,OnroadTrainingHours > 10, OnroadTrainingHours < 1000 ,Maandenrijbewijs < 84 )

# Filter Ex
Correlations <- Correlations %>% filter(Simulator > 0, KM_last12Months > 0
,OnroadTrainingHours > 10, OnroadTrainingHours < 1000 ,Maandenrijbewijs >= 84 )

## NA's veranderen RiskyBs

Correlations <- Correlations %>% mutate(More10KMFirst12 = na_if(More10KMFirst12,
"6"))
Correlations <- Correlations %>% mutate(More10KMFirst12 = na_if(More10KMLast12,
"6"))
Correlations <- Correlations %>% mutate(PhoneUseFirst12 = na_if(PhoneUseFirst12, "6"))
Correlations <- Correlations %>% mutate(PhoneUseLast12 = na_if(PhoneUseLast12, "6"))
Correlations <- Correlations %>% mutate(RedLightFirst12 = na_if(RedLightFirst12, "6"))
```

```
Correlations <- Correlations %>% mutate(RedLightLast12 = na_if(RedLightLast12, "6"))
Correlations <- Correlations %>% mutate(BrakeFirst12 = na_if(BrakeFirst12, "6"))
Correlations <- Correlations %>% mutate(BrakeLast12 = na_if(BrakeLast12, "6"))
Correlations <- Correlations %>% mutate(AlcoholFirst12 = na_if(AlcoholFirst12, "6"))
Correlations <- Correlations %>% mutate(AlcoholLast12 = na_if(AlcoholLast12, "6"))
Correlations <- Correlations %>% mutate(DrugsFirst12 = na_if(DrugsFirst12, "6"))
Correlations <- Correlations %>% mutate(DrugsLast12 = na_if(DrugsLast12, "6"))
Correlations <- Correlations %>% mutate(NoSeatbeltFirst12 = na_if(NoSeatbeltFirst12, "6"))
Correlations <- Correlations %>% mutate(NoSeatbeltLast12 = na_if(NoSeatbeltLast12, "6"))
Correlations <- Correlations %>% mutate(NoVoorrangFirst12 = na_if(NoVoorrangFirst12,
"6"))
Correlations <- Correlations %>% mutate(NoVoorrangLast12 = na_if(NoVoorrangLast12,
"6"))
Correlations <- Correlations %>% mutate(OffRoadFirst12 = na_if(OffRoadFirst12, "6"))
Correlations <- Correlations %>% mutate(OffRoadLast12 = na_if(OffRoadLast12, "6"))


## Variabelen Toevoegen

## Variable Driving exam == 1 or Driving exam > 1
Correlations <- Correlations %>% mutate(FirstPassExam = N_DrivingExam == 1)
Correlations <- Correlations %>% mutate(NoFirstPassExam = N_DrivingExam > 1)

Correlations$Pass.Dummy <- ifelse(Correlations$FirstPassExam=="TRUE",1,0)

##Variable Driving Anxiety and No driving anxiety
Correlations <- Correlations %>% mutate(DrAnxiety = AnxietyStartDriving > 2)
Correlations <- Correlations %>% mutate(NoDrAnxiety = AnxietyStartDriving < 2)
Correlations$DrAnxiety.Dummy <- ifelse(Correlations$DrAnxiety=="TRUE",1,0)

## Sum RiskyBs First 12
Correlations <- Correlations %>% mutate(SumRiskyBFirst12 = More10KMFirst12 +
PhoneUseFirst12 + RedLightFirst12 + BrakeFirst12 + AlcoholFirst12
                        + DrugsFirst12 + NoSeatbeltFirst12 + OffRoadFirst12 +
NoVoorrangFirst12)

RiskyBehaviours <- RiskyBehaviours %>% mutate(SumRiskyBFirst12 = More10KMFirst12
+ PhoneUseFirst12 + RedLightFirst12 + BrakeFirst12 + AlcoholFirst12
                            + DrugsFirst12 + NoSeatbeltFirst12 + OffRoadFirst12 +
NoVoorrangFirst12)

Correlations <- Correlations %>% filter(More10KMFirst12 < 6, PhoneUseFirst12 < 6,
RedLightFirst12 < 6, BrakeFirst12 < 6, AlcoholFirst12 < 6, DrugsFirst12 < 6,
NoSeatbeltFirst12 < 6,
                            NoVoorrangFirst12 < 6, OffRoadFirst12 < 6)
## Sum RiskyBs Last 12
Correlations <- Correlations %>% mutate(SumRiskyBLast12 = More10KMLast12 +
PhoneUseLast12 + RedLightLast12 + BrakeLast12 + AlcoholLast12
                        + DrugsLast12 + NoSeatbeltLast12 + OffRoadLast12 +
NoVoorrangLast12)
```

```
Correlations <- Correlations %>% mutate(SumRiskyBLast12 = More10KMLast12 +
PhoneUseLast12 + RedLightLast12 + BrakeLast12 + AlcoholLast12
                        + DrugsLast12 + NoSeatbeltLast12 + OffRoadLast12 +
NoVoorrangLast12)

Correlations <- Correlations %>% filter(More10KMLast12 < 6, PhoneUseLast12 < 6,
RedLightLast12 < 6, BrakeLast12 < 6, AlcoholLast12 < 6, DrugsLast12 < 6,
NoSeatbeltLast12 < 6,
                              NoVoorrangLast12 < 6, OffRoadLast12 < 6)

# Correlations Riskyb First and Last 12

RiskyBehaviours %>% select(SumRiskyBFirst12$SumRiskyBLast12) %>% cor()



## Descriptive Statistics

Correlations <- Correlations %>% filter(!is.na(KM_first12Months),
!is.na(KM_last12Months))
Correlations <- Correlations %>% filter(!is.na(N_DrivingExam))
Correlations <- Correlations %>% filter(!is.na(Maandenrijbewijs))
Correlations <- Correlations %>% filter(!is.na(SumRiskyBFirst12),
!is.na(SumRiskyBLast12))

Correlations %>% summarise(mean_Kmfirst = mean(KM_first12Months), sdKmfirst =
sd(KM_first12Months))
Correlations %>% summarise(mean_Kmfirst = mean(KM_last12Months), sdKmlast =
sd(KM_last12Months))
Correlations %>% summarise(mean_Onroad = mean(OnroadTrainingHours), sdOnroad=
sd(OnroadTrainingHours))
Correlations %>% summarise(mean_Exam = mean(N_DrivingExam), sdExam=
sd(N_DrivingExam))
Correlations %>% summarise(mean_Licence = mean(Maandenrijbewijs), sdLicence=
sd(Maandenrijbewijs))


Correlations %>% summarise(mean_AccidentFirst = mean(AccidentFirst12),
sdAccidentFirst = sd(AccidentFirst12))
Correlations %>% summarise(mean_AccidentLast = mean(AccidentLast12), sdAccidentLast
= sd(AccidentLast12))

Correlations %>% summarise(mean_RiskFirst = mean(SumRiskyBFirst12), sdRiskfirst =
sd(SumRiskyBFirst12))
Correlations %>% summarise(mean_RiskLast = mean(SumRiskyBLast12), sdRiskLast =
sd(SumRiskyBLast12))


## Regression Modellen (Risky Behaviour)
```

```
model.SumRiskFirst12 <- Correlations%>%
  lm(SumRiskyBFirst12 ~ HazardPerception + KM_first12Months , data = .)
model.SumRiskFirst12 %>%
  tidy()
model.SumRiskFirst12 %>%
  tidy(conf.int = TRUE)

summary(model.SumRiskFirst12)$r.squared

model.SumRiskLast12 <- Correlations%>%
  lm(SumRiskyBLast12 ~ HazardPerception + KM_last12Months + Maandenrijbewijs  , data
= .)
model.SumRiskLast12 %>%
  tidy()
model.SumRiskLast12 %>%
  tidy(conf.int = TRUE)

summary(model.SumRiskLast12)$r.squared


## Assumptions modellen


## Normality (AccidentFirst12 - HP)
hist(residuals(model.AccidentFirst), col = "purple")
shapiro.test(Correlations$AccidentFirst12)
W = 0.31226, p-value < 2.2e-16



## Heteroscadacidy (AccidentFirst12 - HP)
plot(fitted(model.AccidentFirst), residuals(model.AccidentFirst))
abline(h = 0, lty = 2)



## Normality (RiskyFirst12 - HP) --> Normale assumptions
hist(residuals(model.SumRiskFirst12), col = "purple")
shapiro.test(Correlations$SumRiskyBFirst12)
W = 0.90463, p-value < 2.2e-16

library("ggpubr")
ggdensity(Correlations$SumRiskyBFirst12,
          main = "Density plot RiskyBs First 12",
          xlab = "HazardPerception")

##Linearity
qqPlot(Correlations$SumRiskyBFirst12, col = "purple")
```

```
## Heteroscadacidy (RiskyFirst12 - HP)
plot(fitted(model.SumRiskFirst12), residuals(model.SumRiskFirst12))
abline(h = 0, lty = 2)

library(car)
result = leveneTest(AccidentFirst12 ~ HazardPerception, Correlations)
print(result) --> Not appropriate with quantitave data ??



## Normality (RiskyLast12 - HP) --> Normale assumptions
hist(residuals(model.SumRiskLast12), col = "purple")
shapiro.test(Correlations$SumRiskyBLast12)
W = 0.90976, p-value = 4.597e-16


## Linearity (RiskyLast12 - HP)

qqPlot(Correlations$SumRiskyBLast12, col = "purple")


## Heteroscadacidy (RiskyLast12 - HP)
plot(fitted(model.SumRiskLast12), residuals(model.SumRiskLast12))
abline(h = 0, lty = 2)



## Binary Modellen (Passing Driving + Accident)

model.AccidentFirst <- Correlations %>% glm(AccidentFirst12 ~ HazardPerception +
KM_first12Months, data = ., family = binomial )
model.AccidentFirst %>%
  tidy()
model.AccidentFirst %>%
  tidy(conf.int = TRUE)

Correlations$model.AccidentFirst  %>% NagelkerkeR2()



model.AccidentLast <- Correlations %>% glm(AccidentLast12 ~ HazardPerception +
KM_last12Months + Maandenrijbewijs, data = ., family = binomial )
model.AccidentLast %>%
  tidy()
model.Accidentlast %>%
  tidy(conf.int = TRUE)
```

```
Correlations$model.AccidentLast  %>% NagelkerkeR2()

model.FirstPass <- Correlations %>% glm(Pass.Dummy ~ HazardPerception, data = ., family
= binomial )
model.FirstPass %>%
  tidy()
model.FirstPass %>%
  tidy(conf.int = TRUE)

Correlations$model.FirstPass  %>% NagelkerkeR2()
```