Merijn van Niekerk

4343050

MSc Thesis

Analysing the Relation Between Gaze Location and Gap Acceptance Decisions During Highway Merges

Analysing the Relation Between Gaze Location and Gap Acceptance Decisions During Highway Merges

By

Merijn van Niekerk

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Student number:	4343050	
Thesis committee:	Dr.ir.A. Zgonnikov,	TU Delft, Supervisor
	Dr.ir.J.C.F. De Winter,	TU Delft, Supervisor
	Dimitra Doudou.	TU Delft, External member

Preface

This thesis is the final part of the completion of the degree of Master of Science in Mechanical Engineering, Master Track in Vehicle Engineering with specialisation in Dynamics & Control at Delft University of Technology (TU Delft). I enjoyed eight years of studying mechanical Engineering at the TU Delft. In addition to the technical knowledge that I acquired during my studies, I also gained lots of experiences and memories.

This research has been conducted at the TU Delft from September 2020 until July 2022. During this period, I carried out an experiment in which 26 participants were asked to train an autonomous vehicle in how to make the decision of when to merge onto a highway from an on-ramp. During the experiment an eye-tracker monitored the participants' eye movements. The goal was to find what the relation is between eye movements and the decision process during highway merges.

I could not have managed to present this thesis without a lot of people. My first word of thanks goes out to my supervisors Joost de Winter (TU Delft), Arkady Zgonnikov (TU Delft) and Yke Bauke Eisma (TU Delft) for their support and help during my thesis. Joost has helped me to bring my work to a higher level by providing me with critical notes and sharp insights. From the start of my thesis, Arkady's structured way of explaining, his approachability and his enthusiasm helped me in achieving my goals. I appreciated your availability for discussing the problems that I faced and your sincere commitment to help me solve them. Yke, I would like to thank you for your support during the design of the experiment. I appreciated your direct way of communicating.

During my studies I also reached out to my fellow Vehicle Engineering students, Gijs and Justin. Although our projects were very different, it was helpful to discuss my work with you to gain new insights. Then, I would like to thank my fellow Mechanical Engineering master students, with whom I spent most my time during the entire course of my thesis. Annemartijne, Toon, Maurits and Dirk. Our car rides, study-breaks, weekly discussions on current affairs and lunches made this process worth its while. A special thank you to Annemartijne, who was always ready to discuss new insights in my projects.

Third, I would like to thank my parents and brothers for the advice, support and encouragements that you gave me through the years. It helped me in staying motivated and proceeding to achieve my goals. To both my roommates and close friends; thank you for all the great memories that we built during the last eight years. Lastly I would like to thank Jet for always being there for me and supporting me in every step that I take.

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Contents

Analysing the Relation Between Gaze Location and Gap Acceptance Decisions During Highway Merges

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Abstract

Background: Merging on a highway is a complex driving task that requires a lot of interaction with other road users. During these tasks, a driver is required to evaluate gaps in space and time between the themselves and other road users and obstacles in order to arrive at the right moment to merge onto the highway. To improve safety and increase road efficiency, it is necessary to understand the decision process during merging decisions. A way of achieving this, is to understand what visual information humans use during this decision process. This study investigated the relation between gaze location and gap acceptance decisions during highway merges.

Methods: An experiment was performed in which 26 participants monitored an automated vehicle (AV) that was driving on a highway on-ramp. The participants were given the task to train the AV in whether or not to merge in front of an upcoming vehicle that was already driving on the highway. An eye tracker was used to measure gaze data, which was used to find the relation between gaze behaviour and decision outcomes and response times. A mixed-effects logistic model was used for a statistical analysis with decision outcomes as a dependent variable and different gap sizes as predictor variables. A mixed-effects linear model was used to find the relation between response times and dwell times and the different gap sizes and decision outcomes as predictor variables. For both the decision outcome and response time model, dwell time was later included to find the effect on the predictive validity.

Results: The results show that a larger time and distance gap to the upcoming vehicle relate to a higher merging probability. For larger time gaps to the on-ramp, the probability of merging was found to be smaller. It was also found that time gaps to the end of the on-ramp significantly relate to response times, with an increase of 55ms per 1s. Larger time gaps to the upcoming vehicle significantly relates to larger response times, with an increase of 64ms per 1s. No significant relation was found between response time and distance gaps to the upcoming vehicle. The response time was found to be 0.60s longer for rejected gap decisions. The time gap to the end of the on-ramp significantly relates to dwell time, with an increase of 0.56$\%$ per 1s. The distance gap to the upcoming vehicle significantly relates to dwell time, with an increase of 0.60$\%$ per 10m. The time gap to the upcoming vehicle significantly relates to dwell time, with an increase of 0.52$\%$ per 1s. The presented results show as well that a significant relation exists between gaze behaviour and decision outcomes and response times. When analysing decision outcomes and response times, the interaction between dwell time and gap sizes should be taken into account. This improved the predictive validity of the used regression models.

Conclusion: Several pieces of evidence suggest that gaze behaviour assist in understanding the human decision making process during merging. This study can serve as a basis for cognitive models that can investigate how the relation between gaze behaviour and gap sizes, decision outcomes and response times can help to understand and potentially predict gap acceptance decisions.

1 Introduction

An increasing number of newly produced cars have Advanced Driver Assistance Systems (ADAS) [1]. These ADAS need the driver to be in full control and the driver is still required to operate the vehicle at all times. ADAS currently are found to improve the safety of the human driver and passengers as they reduce accidents by human errors [2], [3]. With highly automated vehicles becoming a reality for commercial vehicles, new challenges will arise [4]. Higher automated vehicles will require interaction and communication between the (partly) automated vehicles and human drivers in both the driven vehicle and surrounding vehicles [5].

A mundane task in which this will most likely be the case is when merging from an on-ramp onto the highway. Merging is considered a complex task that requires dynamic human decision processes [6], [7]. When the driver in the vehicle on the on-ramp misjudges the gap to the upcoming vehicle, this could cause hazardous situations. A high level of communication is required between the driver and the surrounding road environment to maintain a safe road environment. When a highly automated driving system takes over the merging tasks that are now performed by the human driver, this level of communication with surrounding traffic should be preserved. At the same time, with traffic density increasing over the years, the need for more efficient merges increases as well [8], [9]. An initial step in ensuring both, is to examine the way that humans make merging decisions and understand not only the outcome of the decision but also understand the process during a merge decision [10], [11].

One approach to understand what information is used to arrive at a decision during a merging manoeuvre, is to examine what visual information human drivers use during the decision process in order to arrive at a final decision. In practice, such an understanding could enable a highly automated vehicle to predict when the driver would merge. During this decision the highly automated vehicle can take into account information about the vehicle's surroundings, and could correct the human driver if the decision is not safe even before the driver has turned the steering wheel. Looking further ahead in the future, understanding the decision process could help AV's to drive in a way that feels natural to human operators, as the vehicle will simulate the same process that a human would. This would as well contribute to a more safe environment, also in the transition from cars driven by humans, to cars driven by autonomous driving systems. In other words: such an examination could help to train an autonomous vehicle (AV) to optimize the way it makes merging decisions in terms of safety and speed. At the same time it could train autonomous vehicles to recognize human errors in mixed traffic environments.

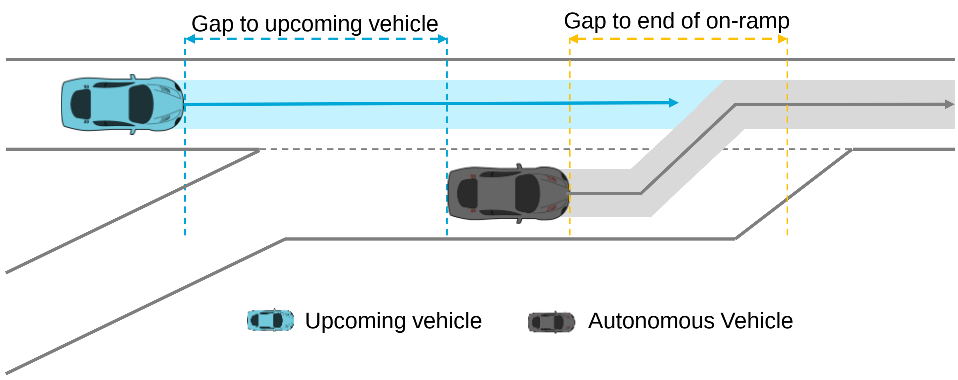

Figure 1: Visual representation of the merging scenario. The Autonomous vehicle needs to consider the gap between both upcoming vehicle and end of the on-ramp before merging onto the highway.

Perception and evaluation of the gap between the driven vehicle and an upcoming vehicle during a merging manoeuvre, can be classified as a gap acceptance decision. Gap acceptance decisions are among the most complex decision processes during driving [12]. In the case of a merging manoeuvre, the driver needs to decide to either accept the gap and merge in front of the upcoming vehicle, or reject the gap and wait to merge behind the upcoming vehicle. At the same time the driver needs to decide before the end of the on-ramp is reached. An AV could do the same by using information from its sensors. An example of a merging scenario is shown in Figure 1. It requires the AV to perceive and process visual information about the surrounding environment and make a decision based on this provided information. The gap to the upcoming vehicle is visible to the driver by gazing towards the side mirror and the gap to the end of the on-ramp is visible by gazing through the front window. Figure 2 displays the two manoeuvres that follow either the accepted gap decision (Figure 2a) or the rejected gap decision (Figure 2b).

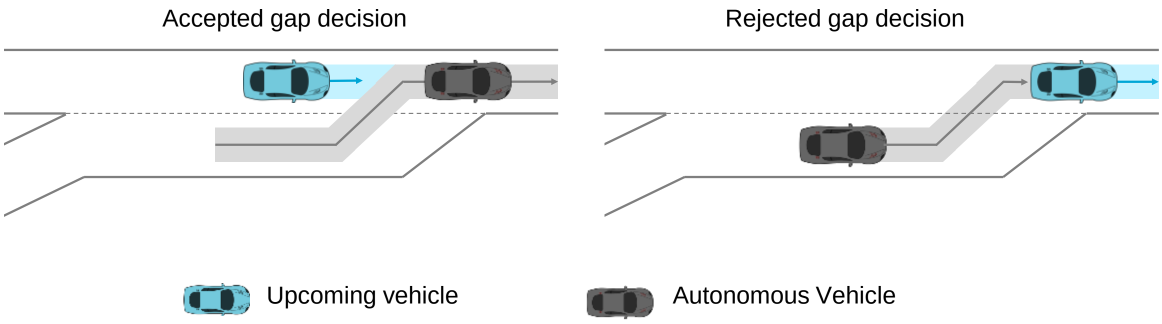

Figure 2 Visual representation of the two decision outcomes. a) The autonomous vehicle accepted the gap and merges in front of the upcoming vehicle. b) The autonomous vehicle rejected the gap and waits for the upcoming vehicle to pass and merges behind it.

Most previous research that has been done on gap acceptance decisions during merging investigated the probability ratio of a gap being accepted. Often the focus is on how the outcome of a decision depends on different influencing factors and not on the decision process [13]–[19]. Many of these studies have shown that the size of the available gap positively impacts the gap acceptance probability. This available gap can be expressed in distance and time. The time gap is determined by the relative speed between the upcoming vehicle and the driven vehicle, together with the relative distance.

Other studies have modelled the decision process of other types of gap acceptance decisions [10], [20], [21]. These studies have modelled underlying cognitive processes by using response time for various situations. Response time gives information about how drivers perceive and process visual information in order to arrive at a decision [22]. For example, a more difficult decision generally results in a longer response time than an easier decision [23]. This response time can as well provide information about the trade-off between speed and accuracy during the decision process [24]. This trade-off suggests that decisions that are made more quickly tend to be less accurate, as the decision maker takes less time to evaluate the situation. Until now, the decision models have not been applied to merging scenarios nor have they considered gaze location as a measurement for cognitive processes during the decision process.

Earlier studies that have investigated gaze behaviour during gap acceptance manoeuvres mainly explained gaze behaviour of human drivers during lane changes [25], [26]. Lane changes are similar to merging manoeuvres but are also very different, as during a lane changes, the driver is not obligated to change lanes before a certain point [27]. Others studies were focussed on the effect of certain, various influencing factors on gaze behaviour during gap acceptance decisions [7], [28], [29]. Until now, these studies did not investigate what the relation is between gap acceptance decisions and gaze behaviour.

Even though the relation between eye movements and gap acceptance decisions has not been investigated, research has shown that a relation exists between other simple decision processes and decision outcomes and gaze location [26], [30]. These findings suggest that a causal relationship between eye movements and the decision making process for simple choice between two visible objects. In these decisions, a relation is found between only the duration that people gazed towards either objects and the decision outcome. The longer the people were looking at an object, the bigger the chance they chose this object. During merging manoeuvres, it is more difficult to determine the effect of gazing towards a certain area of interest, as one area of interest can contain information that steers the driver towards both decision outcomes. For example, a driver evaluating the gap to the upcoming vehicle for a longer period of time could indicate that that the driver is more likely to merge, because he or she finds that the gap is acceptable. However, it could also mean that the same longer gaze provides the driver with more evidence that the gap is not acceptable, resulting in a rejected gap decision. The same goes for evaluating the gap to the end of the on-ramp. Previous studies do suggest that glances to the side mirrors is the most important predictor of drivers' decisions during lane-changes [28], [29], [31]. This could suggest that gaze location and dwell time to the side mirror relates to the decision process during merging manoeuvres.

This study investigated the relation between gaze location and decision outcomes and decision time during merging decisions. If a relation can be found between certain visual elements and decision outcomes and response times, it could become possible to predict decision outcomes and the moment this decision will take place [10]. Accordingly, I analysed gaze locations over time and dwell time to the side mirror of human operators who were required to monitor an automated vehicle that is driving on an on-ramp, with an upcoming vehicle that is driving on the highway behind them. During this monitoring task, the human operator needed to indicate whether they would like the AV to accept or reject the gap between the driven vehicle and the upcoming vehicle. The response time was also taken into account during the analysis.

In this paper a method is proposed to investigate what the relation is between (1) time gaps and (2) distance gaps between an upcoming and the driven vehicle and (3) time gaps between the driven vehicle and the end of the on-ramp and decision outcomes, response times, and gaze behaviour in a merging scenario. Furthermore, I investigated a relation between gaze behaviour and decision outcomes and response times.

I hypothesise that,

- Increasing time and distance gaps to the upcoming vehicle will increase the probability of merging and increase response time for accepted and rejected gap decisions.
- Increasing the time gap to the end of the on-ramp will decrease the probability of merging and decrease response time for merging decisions and increase response time for not merge decisions.
- Increasing time and distance gaps to the upcoming vehicle will decrease the dwell time to the side mirror.
- Increasing the time gap to the end of the on-ramp will increase the dwell time to the side mirror.
- Including dwell time as a predictor variable for decision outcomes and response times in regression models will lead to more accurate predictions of merging decisions.

2 Method

2.1 Subjects

Twenty-six drivers (15 male, 10 female) participated in the experiment. The age of participants ranged between 22 and 60 years (Mean = 25, standard deviation = 7.26). The participants held a driving licence for

8 years on average (SD = 7.46). All participants provided written informed consent (Appendix A). All participants were awarded a €15,- gift-card as a 'show-up fee'. The data of two participants were not analysed due to errors in their data file. Further information about the subjects can be found in Appendix F.

2.2 Apparatus

The experiment was performed using a 24-inch monitor with a resolution of 1920 x 1080 pixels (display area 531*mm* x 298*mm*) combined with the table mount *SR Research EyeLink 1000 Plus* eye tracker. A head support was used to minimize head movements. This head support was adjusted so that the eyes of the participants were on a horizontal line with the top quarter of the screen. The monitor was positioned approximately 1.0*m* in front of the head support, and the lens of the eye tracker was positioned 0.51*m* in front of the head support, in line with the centre of the screen. Figure 3a shows the experimental setup. The experimenter was sitting left to the participant. On the left computer screen the experimenter could see the gaze locations of the participant. This computer screen was not visible for the participant when looking to the experiment screen.

a) b) c)

Figure 3 a) The experimental setup. b) A snapshot of a trial. For each trial the end of the on-ramp and upcoming vehicle are both visible from the starting position. c) Snapshot of the side mirror, showing that the upcoming vehicle is visible from the starting point.

Each driving video consisted of two separate recordings – one of the windscreen view and one of the side mirror view (Figure 3c) – that were created using the *Simcenter Prescan 2019.3.0* software package [32]. Roads, weather, surrounding scenery, vehicles and vehicle control were simulated using this software as well. The two recordings had a framerate of 20 frames per second. The two recordings were merged using *Blender* video editor (Figure 3b). Screenshots of all starting points per condition are shown in Appendix E. The experiment was designed in the *SR Research Experiment Builder* software [33]. An overview of the entire experiment and a snapshot of the 'data collection block' as designed in *Experiment Builder* can be found in Appendix C.

2.3 Experimental design

The experiment consisted of twelve conditions in which the three independent variables were varied (2 time gaps to the on-ramp x 3 distance gaps to the upcoming vehicle x 2 time gaps to the upcoming vehicle), which were repeated 30 times each, adding up to 360 trials in total per participant. In all trials, the participant would encounter a highway merge situation, as visualized in Figure 3b. After every 60 trials, the session was interrupted so that participants could remove their heads from the head support. The order of the conditions was randomized in such a way that each set of 60 trials consisted of 5 times of each condition.

The merge situation consisted of an on-ramp on which an automated vehicle (AV) was driving and an upcoming vehicle already driving on the highway. In each trial, both vehicles were driving at constant speeds, either 22.0*m/s* (~80*km/h*) or 33.0*m/s* (~120*km/h*) for the driven vehicle (AV) and ranging between 25.3*m/s* (~90*km/h*) and 43.0*m/s* (~155*km/h*) for the upcoming vehicle, resulting in time gaps of either 4*s* or 6*s*. At the start of the trial the distance between the upcoming vehicle and AV was either 20*m*, 30*m* or 40*m* and decreased with the relative velocity between the two vehicles. The distance between the driven vehicle and the end of the on-ramp at the start of the trial was kept the same for all twelve videos at 132*m*. The speeds of both the AV and upcoming vehicle were chosen so that the time gaps between both vehicles and between the AV and the end of the on-ramp, were either 4*s* or 6*s* for each trial. The conditions were selected by using metrics found in field studies as a starting point [14] [15]. An iterative process followed in order to find four boundary conditions that would either correspond to 10-20*%* probability of merging or to 80-90*%* probability of merging for each variable. An overview of all condition parameters that were found is shown in Figure 4 and Table 1 below. The same road environment was used to minimize distractions from different surroundings. Video 1, Video 6, Video 7 and Video 12 were the boundary conditions and the other conditions should be somewhere between these conditions.

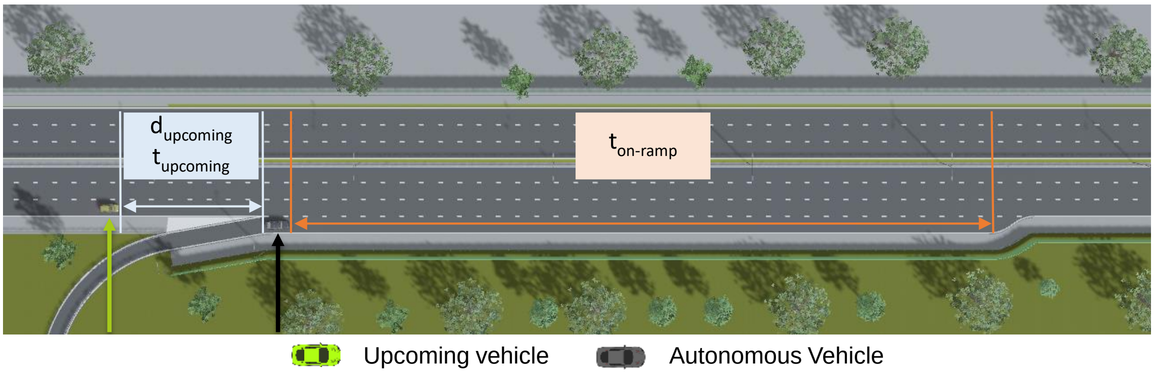

Figure 4 Top view of each merging scenario. The conditions were varied, as presented in Table 1.

For each condition in Table 1 two rectangle areas of interest were predefined using the Experiment Builder software, displayed in orange in Figure 5. The side mirror is defined as Area of Interest 1 (AOI1) and the on-ramp is defined as Area of Interest 2 (AOI2).

	$d_{on\text{-}ramp}$ [m]	$t_{on\text{-}ramp}$ [s]*	v_{AV} [m/s]	$d_{upcoming}$ [m]*	$t_{upcoming}$ [s]*	$v_{upcoming}$ [m/s]
Video 1	132.0	**4.0**	33.0	**20.0**	**4.0**	38.0
Video 2	132.0	**4.0**	33.0	**20.0**	**6.0**	36.3
Video 3	132.0	**4.0**	33.0	**30.0**	**4.0**	40.5
Video 4	132.0	**4.0**	33.0	**30.0**	**6.0**	38.0
Video 5	132.0	**4.0**	33.0	**40.0**	**4.0**	43.0
Video 6	132.0	**4.0**	33.0	**40.0**	**6.0**	39.7
Video 7	132.0	**6.0**	22.0	**20.0**	**4.0**	27.0
Video 8	132.0	**6.0**	22.0	**20.0**	**6.0**	25.3
Video 9	132.0	**6.0**	22.0	**30.0**	**4.0**	29.5
Video 10	132.0	**6.0**	22.0	**30.0**	**6.0**	27.0
Video 11	132.0	**6.0**	22.0	**40.0**	**4.0**	32.0
Video 12	132.0	**6.0**	22.0	**40.0**	**6.0**	28.7

*Table 1 Metrics per video for both AV and upcoming vehicle. *The changing conditions are $t_{on\text{-}ramp}$, $t_{upcoming}$ and $d_{upcoming}$.*

2.4 Experimental task

Participants were first given an introduction about the final goal of this experiment of training the AV when to merge. Furthermore, the instructions mentioned that the participants eye movements were recorded.

Before the experiment started, participants were shown an interactive demo of ten trials. Video 12 was used for this demo. In each of these demo videos, a textual instruction, as shown in Appendix C, was presented on the screen after 2 seconds that would encourage participants to press either LSHIFT or RSHIFT. After the key was pressed, the AV would either merge in front or merge behind the upcoming vehicle, corresponding to the pressed key. This demo was performed to show participants the manoeuvre that corresponds to each instruction, as no such feedback was shown during the actual experiment.

After the demo, participants had to perform twenty practice trials. These trials consisted of the four boundary conditions, as discussed before. Before the practice trials started, the following experimental task was presented on screen:

> *"Imagine you are an expert driver whose job it is to teach an AV How to handle merging situations on a highway. You will view multiple videos of an AV driving in an acceleration lane. You will see that another car is already driving on a highway. Your task is to instruct the AV which situations represent a good opportunity to merge onto a highway, depending on the distance to that car and its speed.*
>
> *Your task is to press LSHIFT if you would like to merge. Alternatively, press RSHIFT if you do not want the AV to merge in front of the approaching car. Please decide just like you would decide when driving on a real road. Press one of the keys as soon as you arrived at your decision.*
>
> *Keep in mind that in the videos, the AV will not actually merge but will stay on the acceleration lane. Keep looking at the video and assess the situation until the video ends."*

During these practice trials, the experimenter monitored the participant to determine whether the participant understood the task correctly. During the monitoring, the decision time and eye movements were evaluated by the experimenter. If needed, further verbal instructions were given to make sure participants understood the task that was given to them.

After the practice trials, final instructions were displayed, explaining to the participants that they would be able to remove their heads from the head support after every set of 60 trials. In additional, the instructions explained that the participant could look away from the screen between every ten videos, while staying in the head support. After the participant pressed a key to continue, their eyes were calibrated. When the calibration was done, the experiment began. If participants chose to remove their head from the head support between the sets of 60 trials, the calibration was performed again before continuing to the next set.

Right before the experiment started, the participants were instructed again to monitor the AV that was driving on an on-ramp and instruct this AV to merge in front of the upcoming vehicle by pressing the LSHIFT key or instruct the AV to wait and merge behind the upcoming vehicle by pressing the RSHIFT key. The entire verbatim instruction is presented in Appendix C. As this was a video-based experiment, no feedback was provided and the video continued playing after a decision was made.

2.5 Dependent variables

After the experiment, three variables were extracted from the recorded data, namely the decision outcome (accept or reject), response time in milliseconds and the participants' gaze location on the screen that was measured at 2000 Hz[1]. For the analysis, the data was down sampled to 20 Hz, which corresponded to one measurement per frame of the videos in each condition.

First, it was determined whether the participant decided to merge in front of the upcoming vehicle. If the participant decided to merge in front of the upcoming vehicle, the decision was marked as 'accepted' and a value of 1 was saved to a data file. If the participant decided to wait and merge behind the upcoming vehicle, this decision was marked as 'rejected' and a value of 0 was saved to the a file.

The response time (RT) was determined by the *Eyelink* software and is the time between the starting of each trial and the moment that the participant presses either the LSHIFT or RSHIFT key. The response time can be described as "perception-reaction time", as it is measured from the moment the perceptual information is presented to the moment a response is executed [34] [23]. The response time was measured for each trial separately.

Figure 5: A snapshot of one trial for one participant in SR Research Dataviewer. The orange rectangles represent the two areas of interest (AOI) that were predefined for each condition, one being the side mirror (AOI1) and the second being the on-ramp (AOI2). If the participant did not look towards one of the areas of interests, "NaN" was outputted for that time frame. The purple and green dots are the gaze locations of the participant – green being the left eye and purple being the right eye. The rectangles, text and dots were not visable for the participant during the experiment.

After the response time was calculated, the dwell time could be determined. The dwell time was calculated separately for Area of Interest 1 (AOI1), Area of Interest 2 (AOI2) and None of both ("NaN") (Figure 5). The outcome is a percentage of time that participants gazed to one of the Areas of Interest. To calculate the dwell time, the cumulative number of video frames that a participant gazed to either of the areas of interest was

[1] For participants 19-26 gaze location was measured at 500Hz instead of 2000Hz due to an error. This was not problematic for the analysis, as this gaze data was down sampled to 20Hz for each participant.

divided by the total number of frames in the time interval between the start of the trial and the moment the decision was made. As the response time was different for each trial, this time interval was different as well.

2.6 Statistical analysis

A mixed-effects logistic model was used for the statistical analysis with decision outcomes as dependent variable and a mixed-effects linear model was used for the analysis with response times and dwell times as dependent variables. The aim was to explain what the relation is between decision outcomes and the different gap sizes as predictor variables. To explain the relation between response times and dwell times, the gap sizes and decision outcomes were used as predictor variables. Additionally the dwell time was added as a predictor for the decision outcome and response time analysis. The different models for decision outcomes and response times were then compared in terms of goodness of fit to determine whether including dwell time will improve the predictive validity.

For the model with decision as the dependent variable, a logistic model was used, in which each 'accepted gap' decision was given a value of 1 and each 'rejected gap' decision was given a value of 0. The linear response time model and the dwell time model were distributed normally.

The corresponding formula for the decision outcome analysis is shown below in Equation 1. The corresponding formula for the response time analysis is shown below in Equation 2. Equation 3 shows the corresponding formula for dwell time. Two additional analyses were done, in which a two-way interaction with each gap and the dwell time to the side mirror was included to investigate the relation between the dwell time and decision outcomes (Equation 4) and dwell time and response times (Equation 5). In each model, the participants' individual behaviour was included as a random effect.

$$Is\_gap\_accepted = 1 + t_{on-ramp} + d_{upcoming} + t_{upcoming} + (1|Participant\_no).$$

Equation 1

$$Response\_time = 1 + t_{on-ramp} + d_{upcoming} + t_{upcoming} + Is\_gap\_accepted \ + (1|Participant\_no).$$

Equation 2

$$Dwell\_time = 1 + t_{on-ramp} + d_{upcoming} + t_{upcoming} + (1|Participant\_no).$$

Equation 3

$$Is\_gap\_accepted = 1 + t_{on-ramp} * Dwell\_time + d_{upcoming} * Dwell\_time + t_{upcoming} * Dwell\_time + (1|Participant_{no})$$

Equation 4

$$Response\_time = 1 + t_{on-ramp} * Dwell\_time + d_{upcoming} * Dwell\_time + t_{upcoming} * Dwell\_time + Is\_gap\_accepted + (1|Participant_{no})$$

Equation 5

The MATLAB Code that was used for all analysis can be found in Appendix G.

3 Results

3.1 Visualisation of gaze behaviour

In general, the drivers' gaze location during the trial was on either the on-ramp or the side mirror (roughly 90%). As well, for each plot in Figure 6, a normal distribution can be recognized from the start of the video (t_0) until the decision is made. The other visualisation plots, which can be found in Appendix B, have similar characteristics to the ones described in this section.

Based on the visual analysis of the gaze location, three time intervals were identified, as shown in Figure 6. First, the interval from t_0 until roughly 0.5 seconds. Second, the interval from 0.5 seconds until the decision is made (marked by Median RT). Third, the interval after the decision was made until the end of the trial.

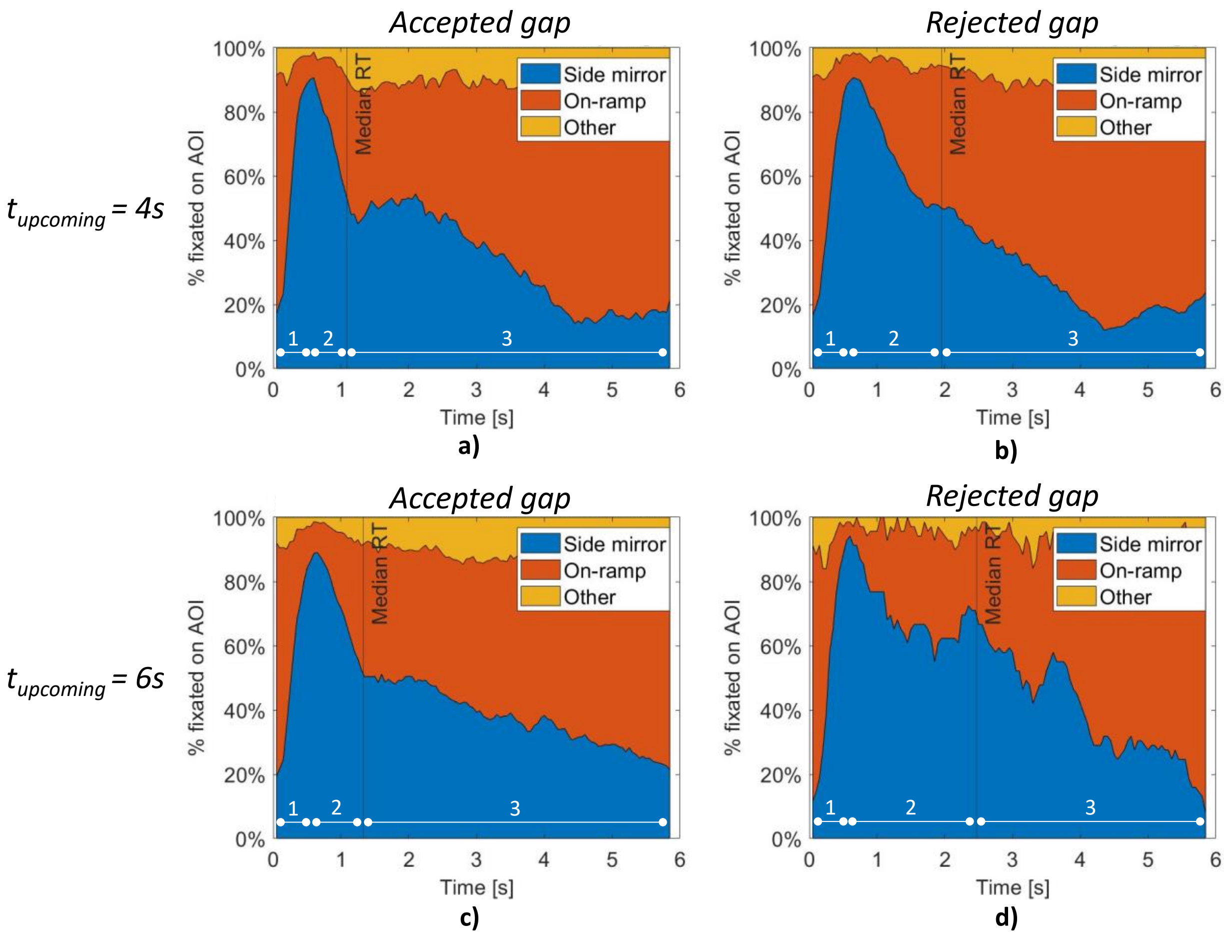

Figure 6: This figure shows a visualisation of the gaze behaviour of all participants for two different conditions (i.e., Video 9 and 10), separated by accepted and rejected gap decisions. The figure shows the percentage of trials in which a participant looked to either the side mirror or the on-ramp (or none of both) in each time frame. One trial represents one time that a condition was shown to a participant. This resulted in a total of 720 events (24 participants x 30 trials per video) for accepted gaps and rejected gaps combined. The conditions shown in Figure 5 have the same time gap to the end of the on-ramp (6 seconds) and the same distance gap to the upcoming vehicle (30 meters). The black vertical line in Figure 5 marked "Median RT", represents the median moment in time that a decision was made. The numbers represent the three time intervals that were identified. a) Time gap to the upcoming vehicle of 4 seconds for accepted gap decisions. b) Time gap to the upcoming vehicle of 4 seconds for rejected gap decisions. c) Time gap to the upcoming vehicle of 6 seconds for accepted gap decisions. d) Time gap to the upcoming vehicle of 6 seconds for rejected gap decisions.

During the first interval, no clear distinction can be made between the different gap sizes or the accepted and rejected gaps in Figure 6. For all plots in Figure 6, the side mirror distribution (blue area) shows a noticeable increase in gaze location from 10-20% at t_0 towards the side mirror up until ~90% at 0.5 seconds. This means that in around 90% of all trials participants' gaze location was on the side mirror at 0.5 seconds. It seems that for all conditions (independent of the decision outcome), the distribution of gaze location is the same in the first 0.5 seconds.

The second time interval shows clear differences in gaze behaviour for different conditions and decision outcomes. In this interval, the distribution to the side mirror decreases (and simultaneously the distribution to the on-ramp increases) to around 50% at the moment a decision is made (median RT). It should be noted that the second time interval is not of constant length for each conditions and decision outcome, but changes with the median response time. Although the time interval changes, the starting- and ending value (in percentage) of gaze location towards the side mirror are roughly the same. The distribution to the side mirror for larger response times, is spread over more time than for smaller response times. When comparing the different time gaps, this means that participants take more time to look at the side mirror for the larger gap, relating to a larger response time. When comparing the accepted and rejected gaps, it shows that participants spend more time looking at the side mirror for rejected gaps, which relates to a larger response time for rejected gaps. Another observation here, is that there is a slight increase of the distribution towards the side mirror directly after the decision is made (outside the second time interval). For the rejected gaps, this increase already starts in the second time interval.

In the third time interval, the distribution towards the side mirror steadily decreases from around 50% towards 10-20%. For some conditions a slight increase of the distribution towards the side mirror is noticed (for some it is more subtle than others), right after the decision was made. For Figure 6a and Figure 6b, a slight increase can be seen after 4 seconds. This corresponds to the moment that the upcoming vehicle passes the driven vehicle. After the decision is made, the distribution towards the side mirror decreases towards 10-20% at the end of each condition.

3.2 Decision outcome analysis

All independent variables are of significant influence on the decision outcome, the results can be found in Table 2.

	Variable	Estimate	SE	tStat	DF	pValue	95% CI
Decision outcome	Intercept	-2.4146	0.080817	-29.878	8630	9.765E-187	[-2.573;-2.2562]
	Time gap to on-ramp	-0.034479	0.0048087	-7.1701	8630	8.115E-13	[-0.043905;-0.025053]
	Distance gap to upcoming vehicle	0.0058023	0.00071695	8.093	8630	6.6111E-16	[0.0043969;0.0072077]
	Time gap to upcoming vehicle	0.38195	0.0099411	38.421	8630	2.786E-298	[0.36246;0.40143]

Table 2: Outcome of regression analysis on decision outcome. A logistic mixed effects model with the participant number as a random effect.

The probability of merging decreases when the time gap to the on-ramp decreases (b = -0.0345 , tStat =-7.17, p = 8.12E-13). As well, it can be concluded that the probability of merging increases with a larger distance gap to the upcoming vehicle (b = 0.00580, tStat = 8.09, p = 6.61E-16). Furthermore, increasing the time gap to the upcoming vehicle also increases the probability of merging (b = 0.382, tStat = 34.42, p = 2.79E-298).

Figure 7 supports the findings of the regression analysis. It shows that a larger median probability of merging for the smaller time gap to the on-ramp. For example, when comparing both 4 second time gaps to the upcoming vehicles in Figure 7a and Figure 7b, the smaller time gap to the on-ramp shows a merging probability of approximately 43%, versus a merging probability of approximately 30% for the larger time gap. Comparing the distance gaps in Figure 7, small differences between the different conditions can be found. When comparing the time gaps of 6 seconds to the upcoming vehicle in Figure 7a and Figure 7e, the smallest distance gap (20*m*) related to the lowest median probability of merging (~97%), and the largest distance gap (40*m*) relating to the highest median probability of merging (~100%). The different time gaps to the upcoming vehicle show a larger difference merging probability. For example, when comparing the two plots in Figure 7c, the results show that for the small time gap, the median amount of accepted gaps is approximately 33% versus approximately 93% for the large time gap.

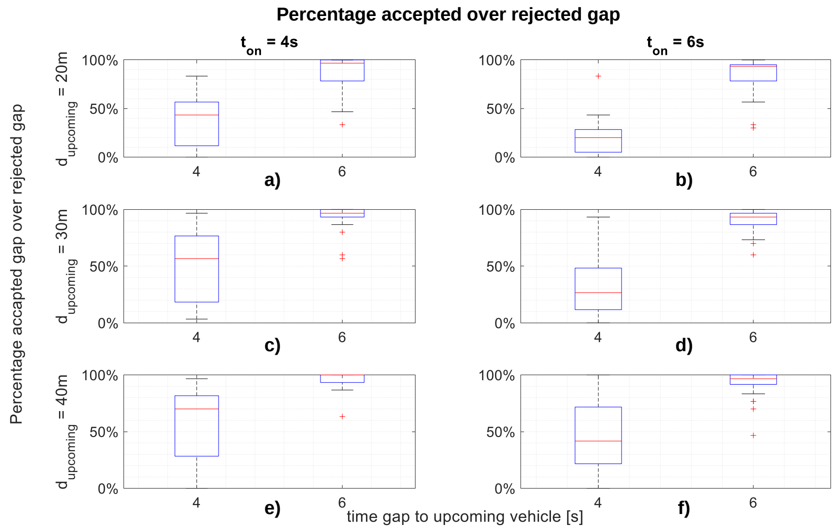

Figure 7 Boxplots of probability of merging for each trial. The twelve boxplots (2 boxplots x 6 figures) each represent one trial. t_{on} displays the time gap to the end of the on-ramp, which was either 4 seconds (left) or 6 seconds (right). $d_{upcoming}$ displays the distance gaps to the upcoming vehicle, which was either 20m (top), 30m (middle) or 40m (bottom). The x-axis displays the time gap to the upcoming vehicle, which was either 4 seconds or 6 seconds. The y-axis of each plot displays the probability of merging.

3.3 Response time analysis

Table 3 shows that the response time is significantly lower for accepted gaps than for rejected gaps, with an average difference of 571*ms* per second (b = -571.04, tStat = -42.19, p = 0). Both the time gaps to the on-ramp and to the upcoming vehicle contribute to a longer response time (b = 55.11 tStat = 16.89, p = 5.55E-63 and b = 64.15, tStat = 10.73, p = 1.12E-26 respectively). This means that, on average, the response times increased 55*ms* per second for the time gap to the on-ramp and 64*ms* per second for the time gap to the upcoming vehicle. For the distance gap to the upcoming vehicle no insignificant impact was found on the response time (b = -0.91, tStat = -1.47, p = 0.14).

	Variable	Estimate	SE	tStat	DF	pValue	95% CI
Response time	Intercept	1362.8	80.694	16.889	8629	5.5534E-63	[1204.6;1521]
	Time gap to on-ramp	55.108	4.9987	11.024	8629	4.4853E-28	[45.309;64.906]
	Distance gap to upcoming vehicle	-0.9071	0.6159	-1.4728	8629	0.14084	[-2.1144;0.30021]
	Time gap to upcoming vehicle	64.153	5.9806	10.727	8629	1.1222E-26	[52.429;75.876]
	Decision outcome	-571.04	13.534	-42.192	8629	0	[-597.57;-544.51]

Table 3: Outcome of regression analysis on response time. A linear mixed effects model with the participant number as a random effect.

Again, these findings are supported by a boxplot analysis, shown in Figure 8. Comparing accepted and rejected gaps, the rejected gap decisions related to a larger response time for all conditions.

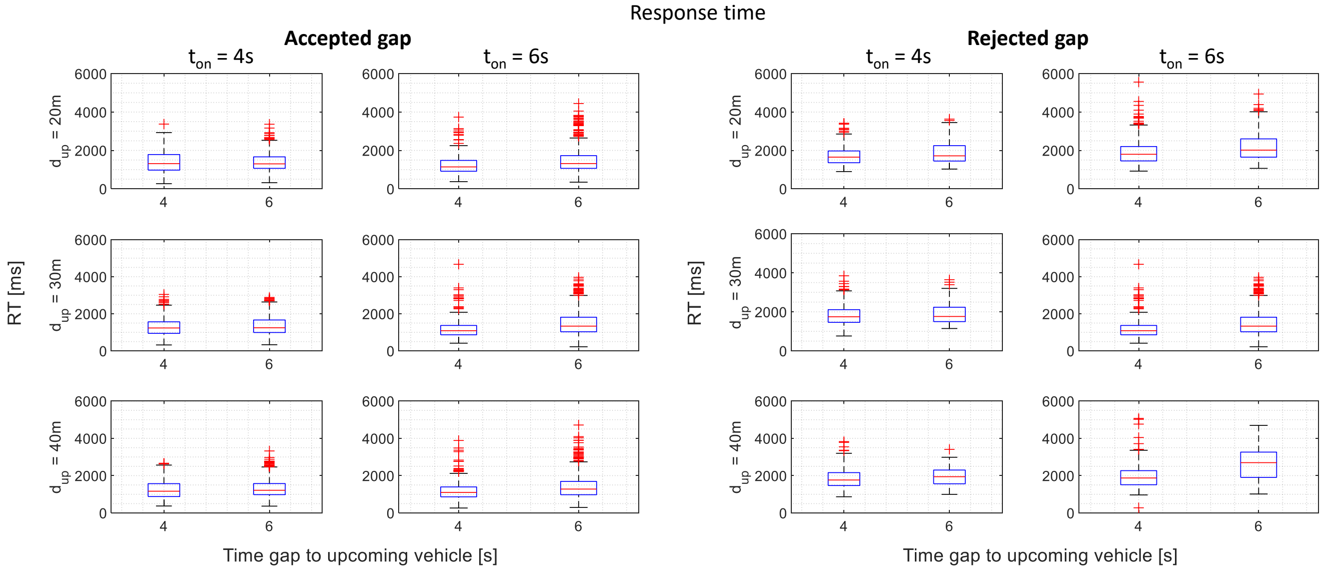

Figure 8 Response time boxplots for all conditions, split by decision outcome. The six figures on the left display the response times for accepted gaps and the six figures on the right display the response times for rejected gaps. t_{on} displays the time gap to the on-ramp, which was either 4 seconds (left) or 6 seconds (right). $d_{upcoming}$ displays the distance gaps to the upcoming vehicle, which was either 20m (top), 30m (middle) or 40m (bottom). The x-axis displays the time gap to the upcoming vehicle, which was either 4 seconds or 6 seconds. The y-axis of each plot displays the response time.

3.4 Dwell time analysis

Table 4 shows that all independent variables are significantly related to the dwell time to the side mirror. It is shown that the dwell time increases with approximately 1.1*%* (2*s* x 0.56*%*) for the larger time gap to the on-ramp vehicle compared to the smaller time gap (b = 0.00558, tStat = 4.018, p = 5.920E-5). The dwell time is around 0.60*%* (10*m* x 0.060*%*) larger for each larger distance gap to the upcoming vehicle (b = 0.000600, tStat = 3.51, p = 0.000452). For the time gap to the upcoming vehicle, the dwell time increased with approximately 1.05*%* (2*s* x 0.53*%*) for the larger time gap compared to the smaller time gap (b = 0.00526, tStat = 3.17, p = 0.00153).

In this analysis, no evidence is found that a relation exists between decision outcomes and dwell time.

	Variable	Estimate	SE	tStat	DF	pValue	95% CI
	Intercept	0.59975	0.030165	19.883	8629	4.7601E-86	[0.54062;0.65888]
	Time gap to on-ramp	0.0055768	0.001388	4.018	8629	5.9198E-05	[0.0028561;0.0082975]
Dwell time	Distance gap to upcoming vehicle	0.00060007	0.00017101	3.5089	8629	0.00045219	[0.00026485;0.0009353]
	Time gap to upcoming vehicle	0.0052649	0.0016607	3.1703	8629	0.0015284	[0.0020095;0.0085203]
	Decision outcome	0.00093454	0.0037589	0.2486	8629	0.80366	[-0.0064337;0.0083028]

Table 4: Outcome of regression analysis on dwell time to the side mirror. A linear mixed effects model with the participant number as a random effect.

Based on Figure 9, no structural differences between the conditions for the dwell time are shown. Not one overall statement can be made in general about the plots. For example, when comparing the small time gap to the on-ramp for accepted gaps, the dwell time is indeed slightly larger for larger time gaps to the upcoming vehicle. However, when comparing the larger time gap to the on-ramp for accepted gaps, it seems more like the opposite is the case: larger time gaps to the upcoming vehicle relate to smaller dwell times.

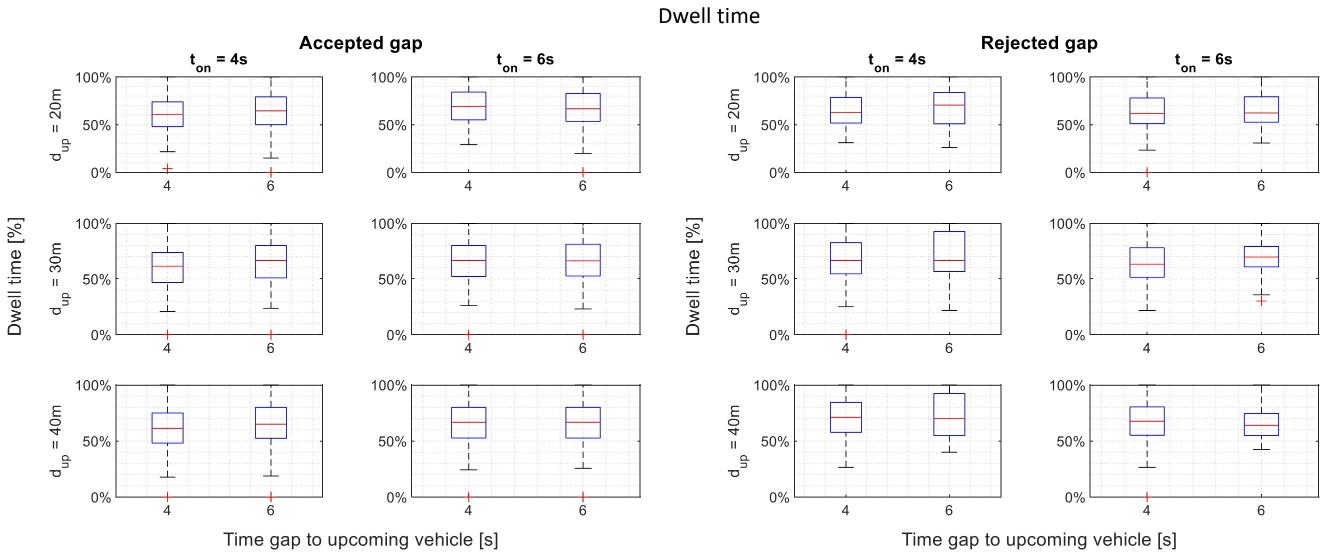

Figure 9 Dwell time box plots. The six figures on the left display the dwell time for accepted gaps and the six figures on the right display the dwell time for rejected gaps. t_{on} displays the time gap to the on-ramp, which was either 4 seconds (left) or 6 seconds (right). $d_{upcoming}$ displays the distance gaps to the upcoming vehicle, which was either 20m (top), 30m (middle) or 40m (bottom). The x-axis displays the time gap to the upcoming vehicle, which was either 4 seconds or 6 seconds. The y-axis of each plot displays the dwell time.

3.5 Including dwell time in regression models

In this section, dwell time is included in the regression models for decision outcomes and response times that were discussed earlier, in order to investigate whether this will improve the fit of each model.

Table 5 shows a significant relation between dwell time and decision outcomes. For the time gap to the on-ramp, a higher probability of merging is shown for a higher dwell time to the side mirror (b = 0.176, tStat = 5.24, p = 1.67). For larger time gaps to the upcoming vehicle, looking longer to the side mirror is related to an increased probability of merging (b = 0.165, tStat = 3.28, p = 0.001). In this analysis, the distance gap to the upcoming vehicle is not proven to have a significant relation with the decision outcome.

The response time analysis in Table 5 shows a significant relation between dwell time and both the time gap to the on-ramp and the time gap to the upcoming vehicle. For the time gap to the on-ramp, a larger dwell time to the side mirror related to a smaller response time (b = -153.33, tStat = -5.89, p = 4.123E-19). For the time gap to the upcoming vehicle, an increased dwell time to the side mirror related to an increased response time (b = 51.68, tStat = 1.99, p = 0.047). It should be noted here that the dwell time is analysed as a percentage (value between 0 and 1).

Including dwell time as a predictor variable in the decision outcome model, shows that dwell time relates to decision outcomes and response times and that it interacts with the different time gap sizes. This means that the influence of dwell time depends on the different time gap sizes. No significant influence of the dwell time was found for the distance gap to the upcoming vehicle.

	Variable	Estimate	SE	tStat	DF	pValue	95% CI
Decision outcome (incl. dwell time)	Intercept	-1.3155	0.25124	-5.2362	8626	1.6776E-07	[-1.808;-0.82306]
	Time gap to on-ramp	-0.1563	0.023758	-6.5789	8626	5.0145E-11	[-0.20287;-0.10973]
	Distance gap to upcoming vehicle	0.0094298	0.002741	3.4403	8626	0.00058386	[0.0040568;0.014803]
	Time gap to upcoming vehicle	0.27215	0.034895	7.7992	8626	6.9538E-15	[0.20375;0.34056]
	% Dwell time to side mirror	-1.6492	0.35659	-4.6249	8626	3.8024E-06	[-2.3482;-0.95018]
	Time gap on-ramp: dwell time	0.17601	0.033607	5.2374	8626	1.6671E-07	[0.11014;0.24189]
	Distance gap upcoming: dwell time	-0.0048786	0.0037431	-1.3034	8626	0.19249	[-0.012216;0.0024588]
	Time gap upcoming: dwell time	0.16533	0.050337	3.2845	8626	0.0010258	[0.066657;0.264]
	Variable	**Estimate**	**SE**	**tStat**	**DF**	**pValue**	**95% CI**
Response time (incl. dwell time)	Intercept	1420.9	158.41	8.9702	8625	3.5838E-19	[1110.4;1731.5]
	Time gap to on-ramp	162.43	18.262	8.8945	8625	7.0571E-19	[126.64;198.23]
	Distance gap to upcoming vehicle	0.57529	2.2243	0.2586	8625	0.79592	[-3.7849;4.9355]
	Time gap to upcoming vehicle	31.703	18.284	1.7339	8625	0.082974	[-4.1387;67.545]
	Decision outcome	-563.91	13.332	-42.297	8625	0	[-590.04;-537.78]
	% Dwell time to side mirror	-158.05	211.83	-0.7461	8625	0.45561	[-573.29;257.18]
	Time gap on-ramp: dwell time	-153.33	26.053	-5.8852	8625	4.1233E-09	[-204.39;-102.26]
	Distance gap upcoming: dwell time	-1.6309	3.183	-0.5124	8625	0.60841	[-7.8704;4.6087]
	Time gap upcoming: dwell time	51.677	25.997	1.9878	8625	0.046867	[0.71621;102.64]

Table 5: Outcome of regression analysis on decision outcome and response time including dwell time to the side mirror. A logistic mixed-effects model and linear mixed-effects model with the participant number as a random effect.

Table 6 shows that the fit of both regression model improves when including dwell time. This means that the predictive validity of the regression models that include dwell time is higher than the model that does not include dwell time. However, the differences between the models are only moderate.

Regression model	AIC	BIC	Loglikelyhood	Deviance	R^2
Decision outcome	7,711	7,746	-3,850	7,701	0.46
Decision outcome (incl. dwell time)	7,666	7,730	-3,824	7,648	0.47
Response time	130,540	130,590	-65,262	130,520	0.48
Response time (incl. dwell time)	130,170	130,250	-65,074	130,150	0.50

Table 6: Model data of the various regression models

4 Discussion

This study aimed to examine what is the relation between gaze location and decision outcomes and response times during merging decisions. Previous studies on gap acceptance decisions have traditionally focussed on final decision outcomes and the factors affecting it [13]–[15]. These studies did not take into account the decision process nor did they investigate the relation between decisions and eye movements. A limited number of studies have focussed on the decision processes during gap acceptance decisions [10], [20], [21]. These studies included varying factors to model decision processes. This study contributes to current research by investigating decision outcomes and response times for merging manoeuvres while taking into account gaze behaviour. In this study, an experiment was performed which was focussed on a merging manoeuvre during which multiple gaps were presented to analyse the gap acceptance decision processes.

4.1 Experimental results

There are multiple different explanations possible on how to interpret the data presented in the result section. In this section a couple interpretations will be discussed.

4.1.1 Decision outcomes

This study was not the first to show that a relation exists between decision outcomes and different gap sizes. Previous studies have shown that the size of the available gap positively impacts the probability of accepting a gap, which leads to a merge [13] [14]. This is in line with the results presented here, which provides evidence that the experimental method was valid.

The results presented here show that the largest differences in merging probability related to time gaps to the upcoming vehicle. A possible explanation could be that drivers consider speed more important when evaluating their decisions. This makes sense, as when the relative distance is very small but the relative speed is zero, the gap could be accepted. But if the relative speed is larger than zero, the gap is closing and will eventually be impossible to accept.

Bias also plays a role during the decision making process [35]. A bias can be caused by the personal preferences of drivers or by the current situation. Because this research investigates a merging manoeuvre – the sole reason to drive on a merging lane is to eventually merge onto the highway – drivers are likely to have a bias towards accepting the gap. This could mean that participants wanted to accept the gap at every trial, and only chose to reject the gap when enough evidence collected that it is not safe merge in front of the upcoming vehicle.

4.1.2 Response time

A question that arises is how to interpret the response times. The response time is crucial for analysing decision processes and outcomes. As explained before, interpreting these response times can give insight into the decision process.

The response time can give information about how participants perceive the complexity of the decisions. A decision that is more difficult typically takes longer [23]. The results show that a larger time gap to the upcoming vehicle relates to an increased response times. This could mean that the complexity of the decision increases with an increased time gap. This could suggest that it is easier to evaluate the relative speed of the upcoming vehicle when it is higher. This suggest that when the upcoming vehicle is driving faster, participants realized more quickly that the gap was not acceptable. Another indicator for more complex decisions would be the distance gap, as closer objects are more easily visible than objects that are further away [36]. Drivers should be able identify speeds and distances of the upcoming vehicle more quickly if it is closer. However, in this paper no evidence was found to support such statements.

Learning also plays a role when interpreting response time [23]. It was found that the time gap to the upcoming is of greater influence on the response time than the distance gap. This makes sense as it was related to the speed of the upcoming vehicle. Even though the relative distance was the same, the upcoming vehicle was driving at different speeds for every condition. The participant had to evaluate twelve different driving speeds for the upcoming vehicle versus only two for the driven vehicle (AV). Considering that people find it difficult to estimate driving speeds, it is likely that participants soon recognized that the AV only drove at two different speeds while still needing to evaluate the speed to the upcoming vehicle per trial [37].

Time gaps related to a larger increase in response time compared to distance gaps. This could be explained by that drivers consider speed to be more important when evaluating their decisions. This makes sense, as when the relative distance is very small but the relative speed is zero, the gap remains available and could be accepted. But if the relative speed is larger than zero, the gap is closing and will eventually be impossible to accept.

The difference in response time can also be explained by time pressure. It is possible that participants experience less time pressure to make a decision when time gaps to the onramp or to the upcoming vehicle were larger, which is in line with previous studies [10]. This could explain the increase in response time for larger time gaps to the end of the on-ramp.

Both time pressure and complexity of a decision cause stress that influences response times and the decision quality [38]. In the case of gap acceptance, stress causes drivers to make a trade-off between making a fast decision or an accurate decision [35] [39]. This speed versus accuracy trade-off can help explain individual decision making behaviour. When making gap acceptance decisions during merging, drivers have to maintain a safe road environment but simultaneously they have to decide before the upcoming vehicle passes them or before they arrive at the end of the onramp, leading to an unconscious speed-accuracy trade-off. Do they prefer to make a slower decision with the possibility that the gap to the upcoming vehicle closes before they decide, or do they prefer to make a bit more risky decision and decide quickly? Considering the speed-accuracy trade-off for the results presented in this paper, this could mean that when drivers had more time to come up with a decision, he or she took more time to evaluate the situation, as taking more time could lead to more accurate decisions [40]. An accurate merging decision means that the merge is performed in a safe way, while complying to social interactions to other drivers [41].

Lastly, response time could also relate to the fact that drivers who are more attentive, are able to evaluate their surroundings more quickly than drivers that are less attentive, enabling them to arrive at a decision more quickly [26]. This could also explain the difference in response time for accepted versus rejected gaps.

4.1.3 Gaze behaviour

This study was the first to investigate the relation between gaze location and decision outcomes and response times for gap acceptance decisions during highway merges. Previous studies already suggested that a causal relation exists between gaze location and the decision process [30], [26]. These studies were focussed on simple choice between two visible objects. These studies found that longer gaze towards one of two objects, resulted in higher likelihood of choosing that object. As well it is suggested that humans tend to focus longer on information that they are processing. Other studies have investigated gaze location and eye movements during lane changes and already suggest that glances to the side mirror are the most important predictor of drivers' decisions for a lane change, which is in line with the results presented in this paper [28], [29]. These studies did not go into the relation between eye movements and the decision process. For gap acceptance decisions, and especially merging manoeuvres, it is more difficult to determine the effect of gazing towards either the side mirror or the end of the on-ramp on merging behaviour.

An important question raised by the presented results is whether gaze location has a causal effect on the decision process. Several pieces of evidence suggest that this might be the case. When looking at Figure 6, differences in distributions towards the side mirror suggest that gaze behaviour in the second time interval is related to the different time and distance gaps. This is supported by the regression analyses: The dwell time regression analysis indicates that the gap sizes were of significant influence on the dwell time. Gap sizes also significantly relate to gap sizes and response times. Additionally, the outcome and response time regressions that include dwell time suggest that including dwell time as a predictor variable in the decision outcome analysis shows that dwell time relates to decision outcomes (Table 5). Furthermore, the results show that the fit of the model is improved when including dwell time while predicting decision outcomes compared to predictions based on gap sizes only. This suggests that participants' gaze location depends on the different gap sizes and that decision outcomes are influenced by gaze location. It should be noted that the dwell time regression (Table 4) does not show a relation between dwell time and decision outcomes and the relation between dwell time and gap sizes is significant but small. This is most likely explained by the statement that dwell time interacts with gap sizes. In other words: the results suggest that dwell time can serve as a predictor for decision outcomes, but only if the gap size is known.

When investigating the decision making processes, bias could also influence the gaze location. It is likely that drivers want to accept the gap and merge onto the highway and are looking for evidence to support this decision, by looking towards the side mirror. Bias could also explain why the slight increase of the distribution towards the side mirror in Figure 6 happens after the decision was made for accepted gaps and before the decision was made for rejected gaps. This would mean that drivers already have enough information to reject the gap, but want to reconsider their decision for a moment before pressing the button, because they would prefer to accept the gap.

4.2 Limitations and recommendations

A limitation to the present study is that it was a video-based experiment. This means that the conditions were fixed and did not change according to the driving style of participants. This is a limitation as it does not resemble the real life situations in terms of speed profiles. Previous studies on how drivers merge onto the highway have shown that speed is not constant during a merging manoeuvre, but constant accelerations and decelerations occur while finding a gap to accept [6], [14], [15]. These dynamic velocities also result in dynamic decisions. For example, a driver could decide to merge at a certain moment, but could later determine that a merge would be unsafe [42]. During this experiment, such adjustments in the initial decision were not possible. Another limitation of the method of this experiment is that the effect of not having a downside was not included in the analysis. During the experiment, no negative feedback was included for participants when they performed a merge that was not safe. It was emphasized during the training videos that participants should drive in a way that they normally would, but it was not analysed whether they actually did. If a downside is added, this could influence the speed versus accuracy trade-off. It is expected that accuracy becomes more important when an inaccurate decision leads to a negative effect for the driver [43]. Furthermore, this experiment also used videos that were performed in the same exact road environment (i.e. the road and surrounding buildings were the same and only one other road user was used). The effect of different road scenarios and the influence of multiple vehicles driving on the high-way or on the on-ramp was neglected in this research. This means gazes towards the surroundings were probably less than they are in real life. It also means that social interactions between drivers are neglected [41]. A solution for the mentioned problems would be to do a simulation experiment in which drivers are able to drive themselves instead of a video-based experiment. Even better would be to do a real-life experiment, as drivers behave differently in simulators than in real life – drivers tend to take more risks in simulator tests [43]. This, however, could be dangerous and very time-consuming.

A limitation in the analysis presented in this paper is that changing behaviour throughout the experiment was not analysed. In the current study, the learning effect due to the use of repetitions of the same condition was neglected. The risk of using the same conditions and repeating them throughout the experiment, is that participants learn from the conditions, which could change their gaze behaviour, response times and decision outcomes. Research has shown that the use of multiple measures for the same response can cause a learning effect in decision making [38]. When participants start to recognize situations, they might arrive to a decision faster, as they had more time to evaluate the situation. This would mean that they do not have to look as long as they did in the first time they came across that scenario. It could also change the gaze patterns. It could be possible that drivers need more saccades between the side mirror and the end of the on-ramp for new scenarios, whereas they only need less for scenarios that they already saw, because they recognize it. Furthermore, participants can also develop a bias towards a decision. Behavioural changes during the experiment can also be caused due to the design of the experiment. The experiment required participants to gaze at a computer screen while doing a repetitive task in a dark room for an hour in total (including breaks). It is likely that attention faded during the course of the experiment [44]. The described effects can be better understood in future studies by investigating differences in response times over the course of the entire experiment. This could help understand to which extent participants are concentrated or paying attention.

Based on the current research, no firm conclusions can be done on what causes the relation between different response times and decision outcomes. A relation could be further investigated with cognitive process modelling. Previous studies have suggested that drivers accumulate evidence to arrive at a certain decision [10], [20], [21]. These so-called evidence accumulation models have been used to model gap acceptance decisions for multiple situations, such as zebra crossings and left-turn decisions. Until now, no such research was done for merging decisions. Understanding the underlying cognitive mechanism that humans use during these decisions can lead to more generalized predictions of gap acceptance decisions during highway merges. Building such a model could help to further investigate the gaze behaviour during the decision process. As well, this could help to predict how dynamic changes in the surrounding environment over the time course of a decision influence human decisions and gaze behaviour. Such a model could also help explain the influence of bias towards accepting a gap and the related response times. For example, it could be that more evidence needs to be accumulated to reject a gap and it could take longer to make such a decision. The present study is also important for the practical application of such models. Current models are not able to predict decisions during the decision process based on human preferences. For example, models that use changing gap sizes to predict decision outcomes, do not take into account changing personal preferences (i.e. the same situation does not always result in the same decision) [10]. Because eye data can be measured continuously in real time, the current study can contribute to building a model that is able to explain and potentially predict decisions based on these eye movements.

When analysing decision making and gaze behaviour, first the difference between individual drivers should be analysed. It is advisable to go into personal preferences while modelling behaviour [45]. The visualization plots presented in this paper could be further investigated for each individual participant, in order to find how each individual processed the visual data. Multiple studies have shown that driving styles are influenced by gender, age, educational level and driving experience [16]–[19]. This is also the case for merging decisions [46]. Other studies suggest that driving style relates to eye movements during lane change decisions [47]. Including such differences in a model could improve the predictive validity.

5 Conclusion

The aim of this research was to analyse the relationship between gaze location, decision outcomes and response times for merging manoeuvres. This research was the first to analyse gaze location while investigating gap acceptance decisions during highway merges. To measure the influence of time and distance gaps on the gap acceptance decision outcomes, response times and gaze location over time, the time and distance gap between the AV and the upcoming vehicle and between the AV and the end of the onramp were varied during the experiment. The gaze location was used to measure the dwell time to the side mirror, which was included in a regression model to investigate if this would improve this model. From the studied experimental data, the following can be concluded:

- A significant relation was found between gap sizes and decision outcomes for gap acceptance decisions during merging manoeuvres. Larger time- and distance gaps to the upcoming vehicle relate to a higher merging probability. For larger time gaps to the on-ramp, the probability of merging was found to be smaller.
- It was found that time gaps to both upcoming vehicle and end of the on-ramp significantly relate to response times, with an increase of 55*ms* per 1*s*. Larger time gaps significantly relate to larger response times, with an increase of 64*ms* per 1*s*. No significant relation was found between response time and distance gaps to the upcoming vehicle.
- Response time is significantly relates to decision outcomes. The response time was found to be 0.60*s* longer for rejected gap decisions.
- It was found that the distribution of gaze location changes with gap sizes, decision outcomes and response times. It was also found that this distribution was different for accepted and rejected gaps and different response times.
- A significant relation was found between all gap sizes and dwell time during merging decisions. The time gap to the end of the on-ramp significantly relates to dwell time, with an increase of 0.56*%* per 1*s*. The distance gap to the upcoming vehicle significantly relates to dwell time, with an increase of 0.60*%* per 10*m*. The time gap to the upcoming vehicle significantly relates to dwell time, with an increase of 0.52*%* per 1*s*.
- The presented results show that a significant relation exists between dwell times and decision outcomes and response times. When analysing decision outcomes and response times, the interaction between dwell time and gap sizes should be taken into account. This improved the predictive validity of the used regression models.

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Appendix A. Informed Consent Form

Informed Consent Form

Researchers:
MSc student: M.P. van Niekerk
E-mail: M.P.vanNiekerk@student.tudelft.nl
Tel: +31 (0)6 50123774

Supervisor: Dr.ir. J.C.F. de Winter
E-mail: j.c.f.dewinter@tudelft.nl

Supervisor: Dr.ir. Y.B. Eisma
E-mail: y.b.eisma@tudelft.nl

Supervisor: Dr.ir. A. Zgonnikov
E-mail: a.zgonnikov@tudelft.nl

Location:
Delft University of Technology
Faculty of Mechanical, Maritime and Material Engineering
Department of Cognitive Robotics
Mekelweg 2, 2628 CD, Delft
Room 34-C-K-300

This document describes the purpose of this research, procedures of the experiment, risks of participating, the right to withdraw, data collection practices, and preventative measures related to COVID-19. Please read all sections carefully and answer the questions on page 3.

Purpose of the research

The aim of this experiment is to investigate the relation between eye movements and the decision process during highway merging. The results of the study may be useful for designing future road safety systems for cars.

Experiment procedure

During the experiment, your will position your head comfortably on a desk-mounted head support to keep your head still during the experiment.

During the experiment, you will monitor short videos from the perspective of a human driver in a car driving on a highway on-ramp. In each video, you are asked to indicate when you have decided to merge in front of an upcoming vehicle or brake and merge behind the upcoming vehicle, by pressing a key on a keyboard. During each video, your eye movements are tracked by the eye-tracker. Please behave in a similar way as you would when driving a real car.

Risk of participating

There are no expected risks to participants. If you experience any discomfort, please inform the experiment supervisor so the simulation can be stopped. You may take your head out of the headrest any time if you feel unwell.

Procedure for withdrawal from study

Your participation is completely voluntary, and you may stop at any time during the experiment for any reason. There will be no negative consequences for withdrawing from the experiment.

Data treatment

All data collected during the experiment will be stored anonymously for thirty years and used for the purpose of academic research only. When used in publications, all gathered data will be strictly anonymous as well. This signed consent from will be kept by Dr.ir. J.C.F. de Winter in a dedicated locker.

Prevention of the spread of COVID-19

To minimize the risk of COVID-19, you may not participate if you:

- Show symptoms indicative of COVID-19
- Have been in contact with COVID-19 patients within the last 14 days
- Are over the age of 65

The following preventative measures will be required for you to participate:

- Wash your hands thoroughly before entering the lab
- Keep at least 1.5 meters from the researcher and other people inside the lab
- Wear a face mask when in the lab (provided by us if needed)

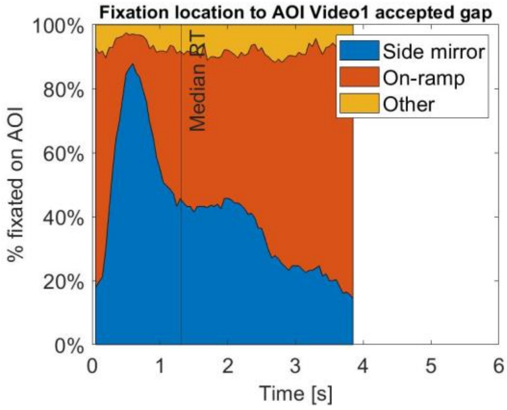
Please answer the following questions:	**Yes**	**No**
I consent to voluntarily participate in this study	○	○
I have read and understood the information provided in this document	○	○
I adhere to the preventative measures with regards to COVID-19 as explained above	○	○
I understand that I can withdraw from the study at any time without any negative consequences	○	○
I consent that the data gathered during the experiment may be used for a MSc thesis and possible future academic research and publications	○	○

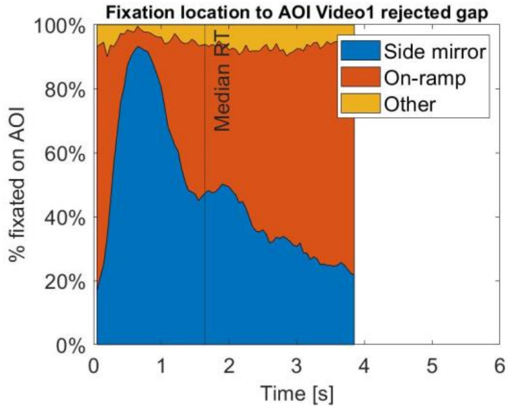
Name:

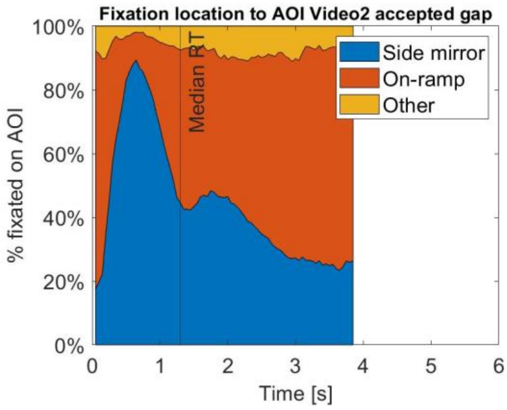
Date:

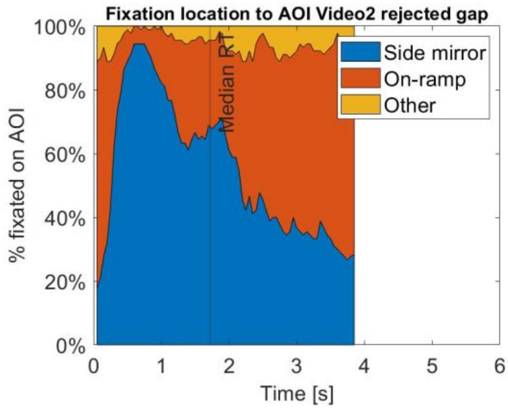
Signature:___________________

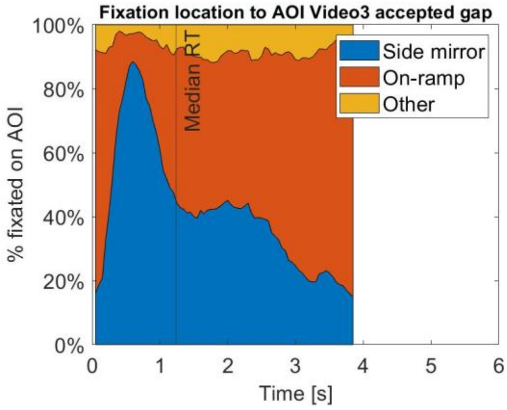
Appendix B. EXTENSIVE RESULTS

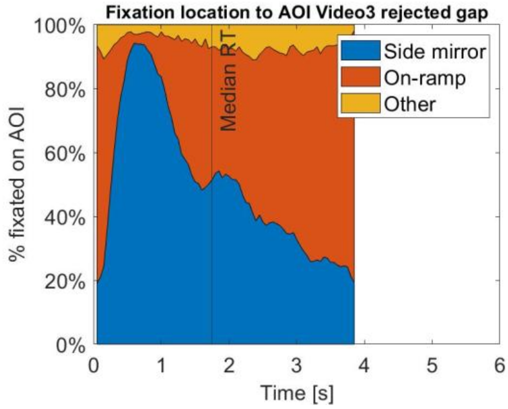


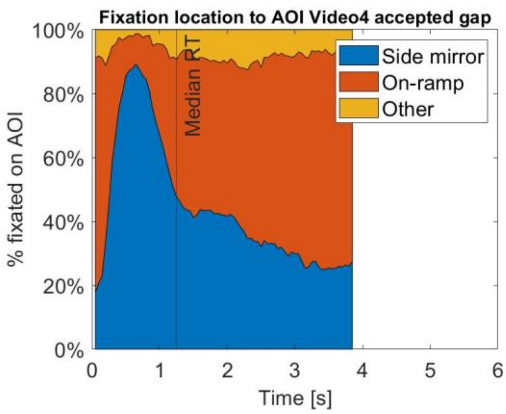


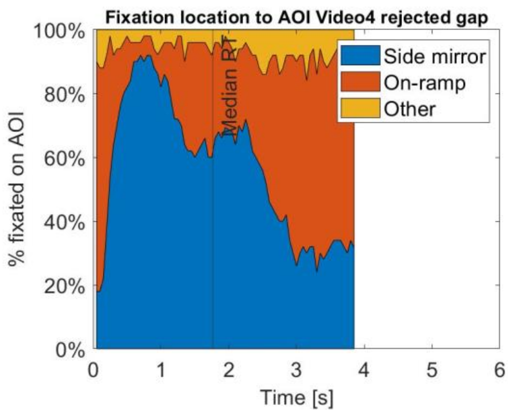


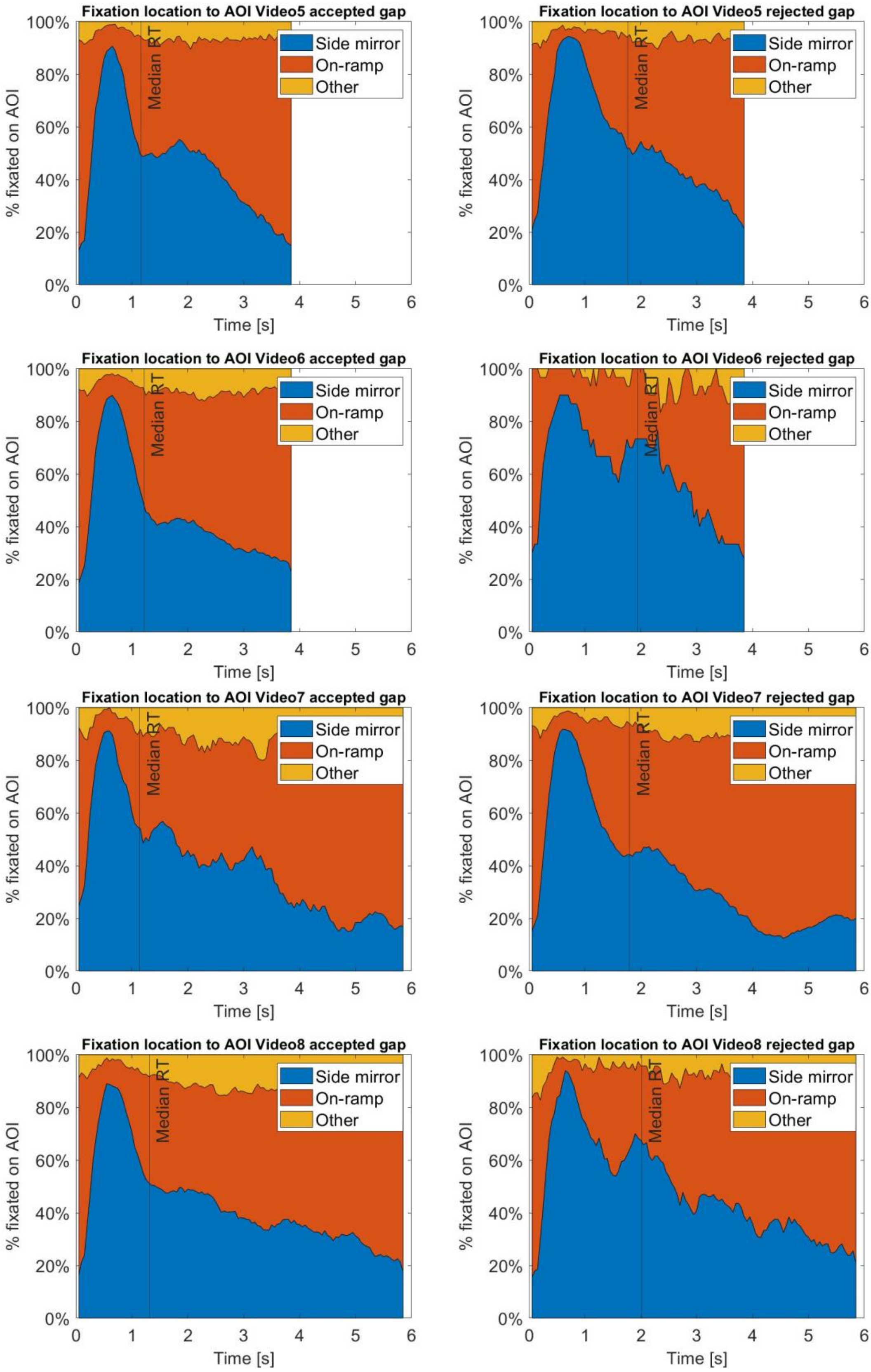


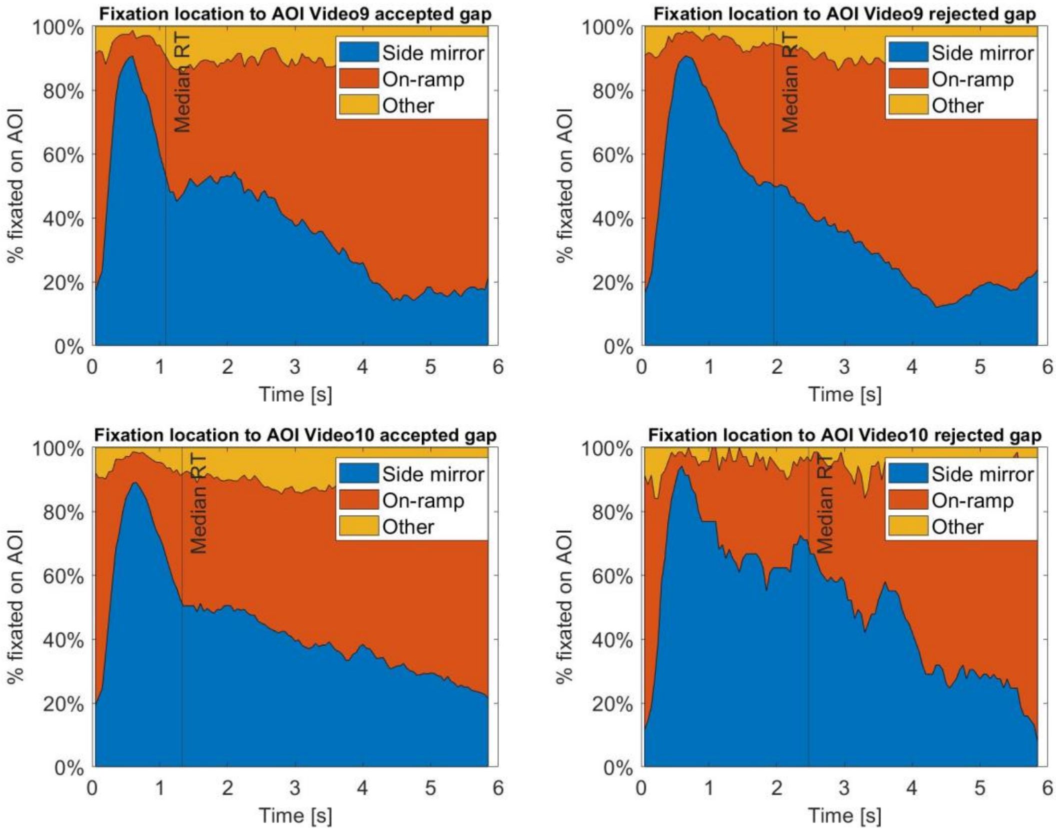






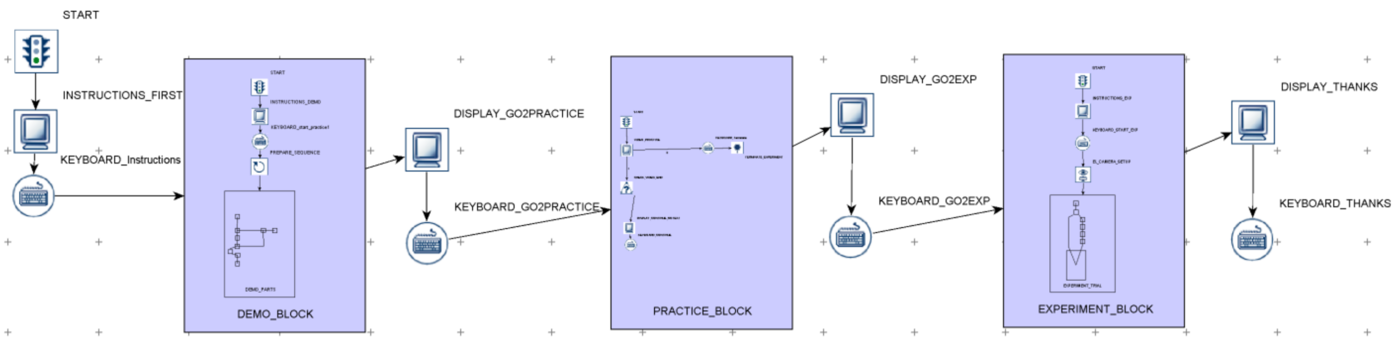



Fixation location to AOI Video5 accepted gap
Fixation location to AOI Video5 rejected gap
Fixation location to AOI Video6 accepted gap
Fixation location to AOI Video6 rejected gap
Fixation location to AOI Video7 accepted gap
Fixation location to AOI Video7 rejected gap
Fixation location to AOI Video8 accepted gap
Fixation location to AOI Video8 rejected gap
% fixated on AOI
Time [s]
Median RT
Side mirror
On-ramp
Other
0%
20%
40%
60%
80%
100%
0
1
2
3
4
5
6

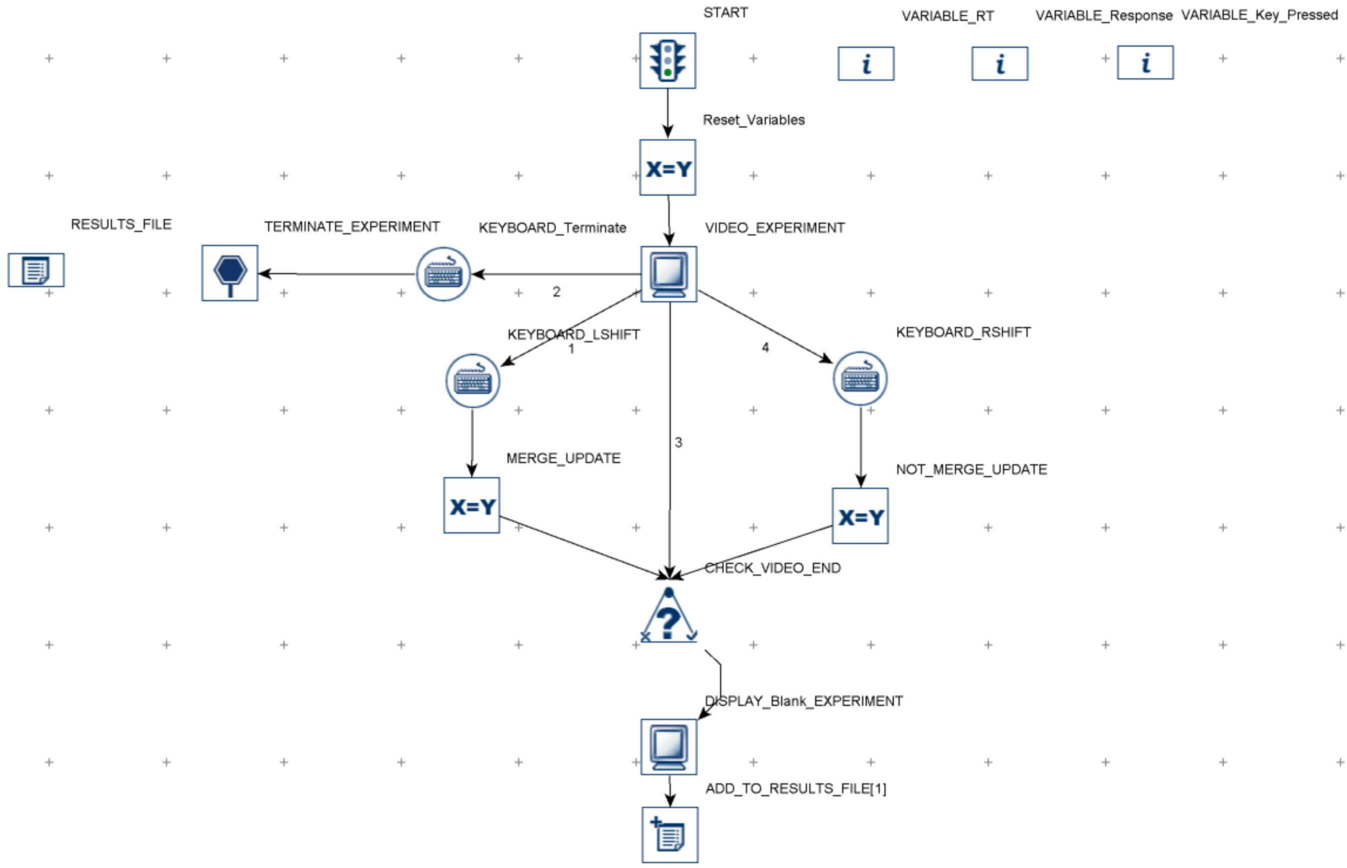

Fixation location to AOI Video9 accepted gap
Fixation location to AOI Video9 rejected gap
Fixation location to AOI Video10 accepted gap
Fixation location to AOI Video10 rejected gap
Side mirror
On-ramp
Other
Median RT
% fixated on AOI
Time [s]
0%
20%
40%
60%
80%
100%
0
1
2
3
4
5
6

Appendix C. EXPERIMENT DESIGN

Overall experiment design, including demo and practice trials.



Actual experiment in which data was collected.



Demo of merging scenario. . When the screen paused and white text appeared as shown below (after 2 seconds), the participant needed to press the LSHIFT key. After pressing the key, the video continued playing and the driven vehicle would merge in front of the upcoming vehicle.

Demo of merging scenario. When the screen paused and white text appeared as shown below (after 2 seconds), the participant needed to press the RSHIFT key. After pressing the key, the video continued playing and the driven vehicle would slow down and merge behind the upcoming vehicle.

Appendix D. Verbatim instructions

INSTRUCTIONS

Automated vehicles (“AV”) cannot drive independently yet. They need to learn from human drivers how to assess risk and when to complete complex maneuvers such as highway merging. The goal of this experiment for you is to make merging decisions. Your results will be useful for creating models of human decision-making and designing autonomous vehicles.

During the experiment, your eye movements will be recorded by an eye tracker.
If for any reason you do not want to continue with the experiment, you can quit whenever you like.

[press any key to continue]

DEMO

You will now view several demo videos which demonstrate how the AV merges into a highway in front or behind the upcoming car.

During the videos you will be instructed to press either LSHIFT or RSHIFT.

A "merge in front" decision (LSHIFT) will cause the AV to merge in front of the car that comes from behind.
A "not merge in front" decision (RSHIFT) will cause the AV to wait for the upcoming car to pass and then merge behind that car.

After you have pressed the button, the corresponding maneuver will be initiated.

[Press any key to continue]

PRACTICE

You will now perform 20 practice trials similar to what you will do during the rest of the experiment. The goal is for you to learn the task. The videos that you will view will not contain any instructions, it is now up to you to decide when to press LSHIFT or RSHIFT.

Imagine you are an expert driver whose job is to teach AVs how to handle merging situations on a highway. You will view multiple videos of an AV driving in an acceleration lane. You will see that another car is already driving on a highway. Your task is to instruct the AV which situations represent a good opportunity to merge onto a highway, depending on the distance to that car and its speed.

Your task is to press LSHIFT if you would like the AV to merge in front of the approaching car on the highway. Alternatively, press RSHIFT if you do not want the AV to merge in front of the approaching car. Please decide just like you would decide when driving on a real road.
Press one of the keys as soon as you arrived at your decision.

Keep in mind that in the videos, the AV will not actually merge but will stay on the acceleration lane. Keep looking at the video and assess the situation until the video ends.

[Press any key to continue]

EXPERIMENT

The real experiment will now begin.

You will be shown six sets of 60 videos just like the videos you just saw during practice. The videos will be shown directly after each other, with a break after every 10 videos.

The task is still the same as during the practice: instruct the AV which situations are a good opportunity to merge (LSHIFT) and which are not (RSHIFT). Remember: please respond just like you would decide when driving on a real road.

[press any key to continue]

Set 1: Text

EXPERIMENT

Please indicate for each video whether you would:
Merge in front ("LSHIFT") or Not Merge in front ("RSHIFT").

You are now able to remove your head from the headmount.

Before the experiment continues, your eyes will be calibrated

If by any circumstance you do not want to continue with this experiment, you are free to do so.

[press any key to continue]

Appendix E. SNAPSHOT OF THE STARTING POINT OF EACH CONDITION

Video 1:

Video 2:

Video 3:

Video 4:

Video 5:

Video 6:

Video 7:

Video 8:

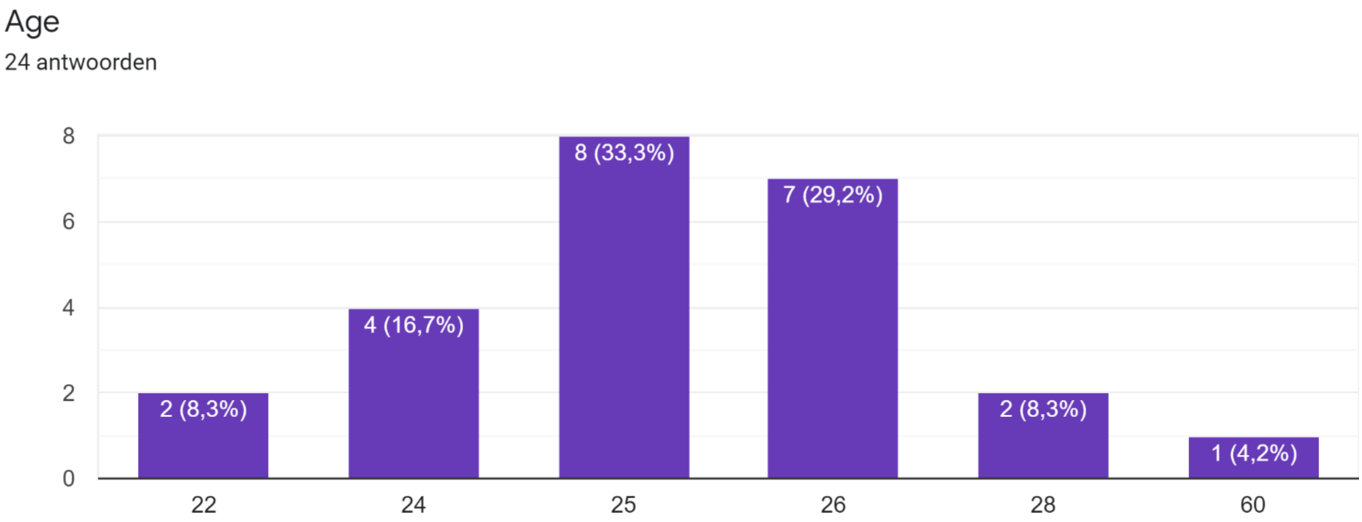
Video 9:

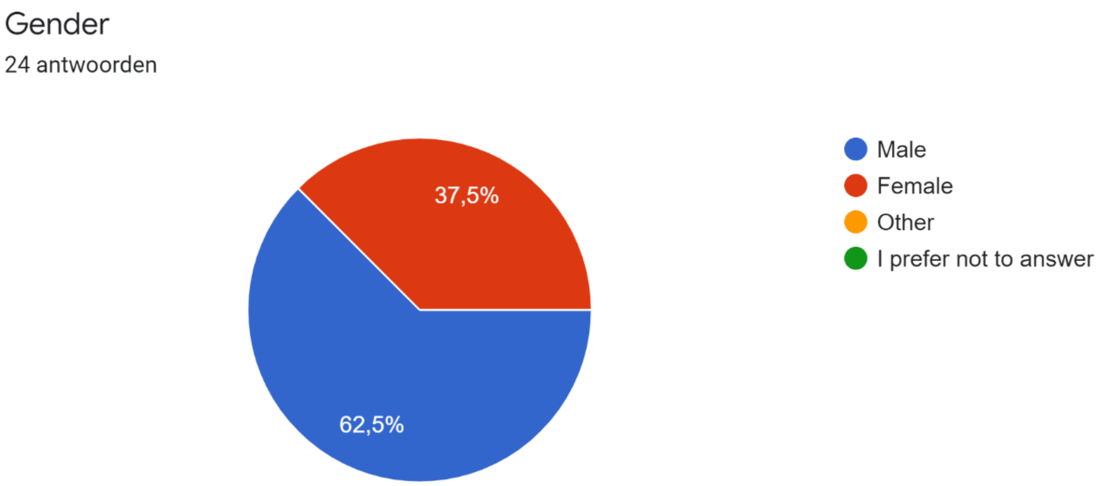
Video 10:

Video 11:

Video 12:

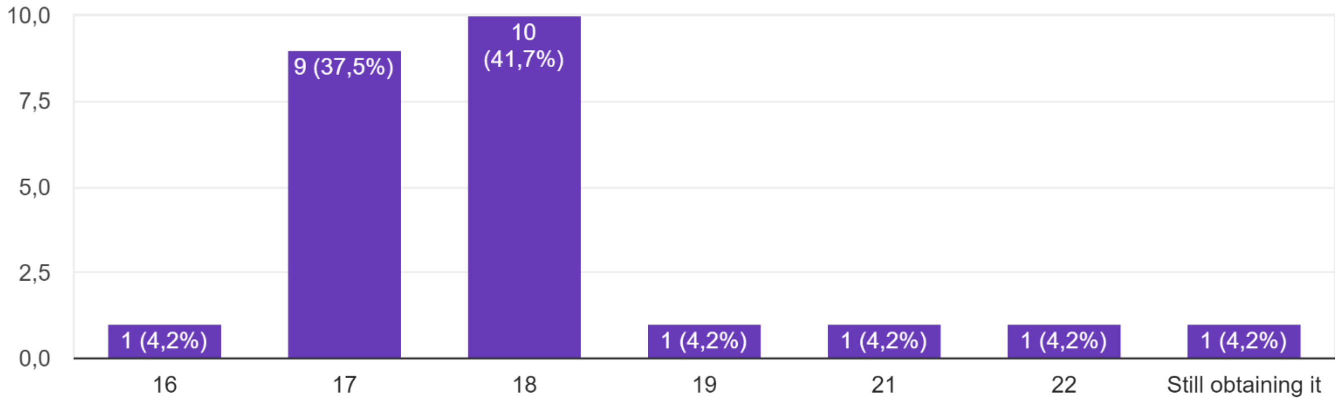
Appendix F. PARTICIPANT INFORMATION





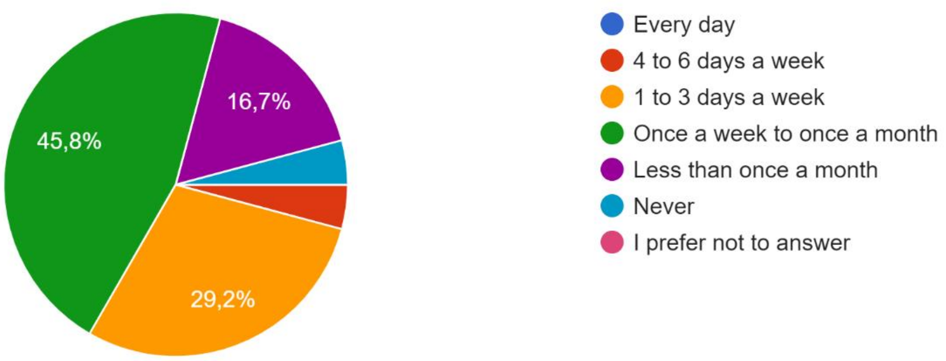
At which age did you obtain your first driver's licence?

24 antwoorden



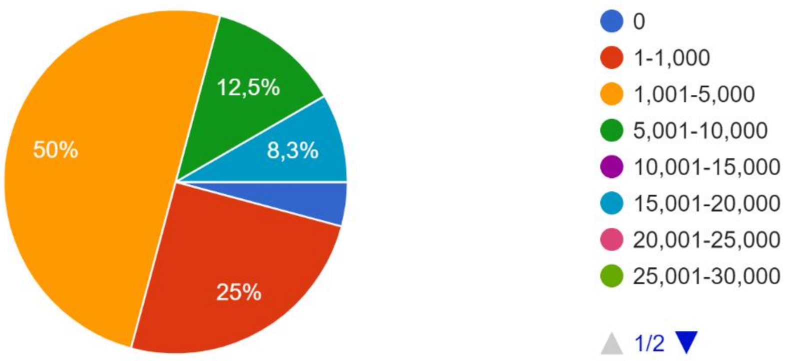
On average, how often did you drive a vehicle in the last months?

24 antwoorden



Roughlly how many kilometers did you drive in the last 12 months?

24 antwoorden



Appendix G. MATLAB Code

```
%% Thesis Merijn van Niekerk
% Student number: 4343050

clear all
close all

validation = ["Part3", "Part4", "Part5", "Part6", "Part7", "Part8", "Part9", "Part10",
"Part11", "Part12", "Part13", "Part14", "Part15", "Part16", "Part17", "Part18", "Part19",
"Part20", "Part21", "Part22", "Part23", "Part24", "Part25", "Part26"];
%LL = validation;
%% Import data from text file. This takes a long time. You can also load from file (see below)
for LL = validation
%% Import data from text file
% Script for importing data from the following text file:

%% Setup the Import Options and import the data
opts = delimitedTextImportOptions("NumVariables", 10);

% Specify range and delimiter
opts.DataLines = [2, Inf];
opts.Delimiter = "\t";

% Specify column names and types
opts.VariableNames = ["RECORDING_SESSION_LABEL", "VIDEO_NAME", "TRIAL_INDEX",
"VARIABLE_Key_Pressed", "VARIABLE_Response", "VARIABLE_RT", "AVERAGE_GAZE_X", "AVERAGE_GAZE_Y",
"AVERAGE_INTEREST_AREAS", "VIDEO_FRAME_INDEX"];
opts.VariableTypes = ["string", "string", "double", "string", "double", "double", "double",
"double", "string", "double"];

% Specify file level properties
opts.ExtraColumnsRule = "ignore";
opts.EmptyLineRule = "read";

% Specify variable properties
opts = setvaropts(opts, ["RECORDING_SESSION_LABEL", "VIDEO_NAME", "VARIABLE_Key_Pressed",
"AVERAGE_INTEREST_AREAS", "VIDEO_FRAME_INDEX"], "EmptyFieldRule", "auto");

% Import the data
% eigen PC
folder =
fullfile('C:\Users\Merijn\Desktop\Experiment\Experiment\Results',LL,'Output\Results_xy.txt');
% TU PC
%folder = fullfile('C:\Users\mvanniekerk\Downloads\Results',LL,'Output\Results_xy.txt');

Rawdata = readtable(folder, opts);

%downsample to 20hz = one datapoint per video frame
if LL == "Part19"
Rawdata_down = downsample(Rawdata,25);
elseif LL == "Part20"
Rawdata_down = downsample(Rawdata,25);
elseif LL == "Part21"
Rawdata_down = downsample(Rawdata,25);
elseif LL == "Part22"
Rawdata_down = downsample(Rawdata,25);
```

```
elseif LL == "Part23"
Rawdata_down = downsample(Rawdata,25);
elseif LL == "Part24"
Rawdata_down = downsample(Rawdata,25);
elseif LL == "Part25"
Rawdata_down = downsample(Rawdata,25);
elseif LL == "Part26"
Rawdata_down = downsample(Rawdata,25);
else
Rawdata_down = downsample(Rawdata,100);
end

% redefine AOI's
Rawdata_down.AVERAGE_INTEREST_AREAS = replace(Rawdata_down.AVERAGE_INTEREST_AREAS,"[]","NaN");
Rawdata_down.AVERAGE_INTEREST_AREAS = replace(Rawdata_down.AVERAGE_INTEREST_AREAS,"[ 1
]","AOI1");
Rawdata_down.AVERAGE_INTEREST_AREAS = replace(Rawdata_down.AVERAGE_INTEREST_AREAS,"[ 2
]","AOI2");

%% Clear temporary variables
clear opts

%% Split for video's showed
  %  Index1 = find(contains(Rawdata.VIDEO_NAME, 'Thesis_Pilot_20m_33ms.mp4'));
  %  Index2  = find(contains(Rawdata.VIDEO_NAME, 'Thesis_Pilot_50m_40ms.mp4'));

   % Vid1_{i} = [Rawdata(Index1,:)];
   % Vid2_{i} = [Rawdata(Index2,:)];

     for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
         for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7",
"Video8", "Video9", "Video10", "Video11", "Video12"]
             for AOI = ["NaN", "AOI1", "AOI2"]
                 for TRIAL_INDEX = 1:320
                x = Rawdata_down.VARIABLE_Response(Rawdata_down.VIDEO_NAME ==
append(vids,".mp4") &  Rawdata_down.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed &
Rawdata_down.AVERAGE_INTEREST_AREAS == AOI);  % &  Rawdata.VARIABLE_Key_Pressed ==
VARIABLE_Key_Pressed  &  Rawdata.AVERAGE_INTEREST_AREAS == AVERAGE_INTEREST_AREAS  &
Rawdata.VIDEO_FRAME_INDEX > 0
                y = Rawdata_down.VIDEO_FRAME_INDEX(Rawdata_down.VIDEO_NAME ==
append(vids,".mp4") &  Rawdata_down.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed &
Rawdata_down.AVERAGE_INTEREST_AREAS == AOI);
                trial = Rawdata_down.TRIAL_INDEX(Rawdata_down.VIDEO_NAME == append(vids,".mp4")
&  Rawdata_down.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed &
Rawdata_down.AVERAGE_INTEREST_AREAS == AOI);
                RT = Rawdata_down.VARIABLE_RT(Rawdata_down.VIDEO_NAME == append(vids,".mp4") &
Rawdata_down.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed & Rawdata_down.AVERAGE_INTEREST_AREAS
== AOI);
                D_out.(vids).(VARIABLE_Key_Pressed).(AOI).(LL) = [x,y];
                D_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL) = [x,y,trial,RT];

                abs.(vids).(VARIABLE_Key_Pressed).(LL) = size(x,1);
                RT_total.(vids).(VARIABLE_Key_Pressed).(LL) =
Rawdata_down.VARIABLE_RT(Rawdata_down.VIDEO_NAME == append(vids,".mp4") &
Rawdata_down.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed);
                %merge.(LL).(vids) = [abs.(vids).(VARIABLE_Key_Pressed).(LL)];
                 end
             end
```

```
        end
    end

    %% second.
for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
        for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7",
"Video8", "Video9", "Video10", "Video11", "Video12"]
            for AOI = ["NaN", "AOI1", "AOI2"]
               for i = 1:120
              IA_stack.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(i,1) =
sum(D_out.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(:,2)==i);

               end
            end
        end
end

end

%% Load data from file. This is the quicker version.

validation = ["Part3", "Part4", "Part5", "Part6", "Part7", "Part8", "Part9", "Part10",
"Part11", "Part12", "Part13", "Part14", "Part15", "Part16", "Part17", "Part18", "Part19",
"Part20", "Part21", "Part22", "Part23", "Part24", "Part25", "Part26"];
LL = validation;
load('data_files.mat')

%% Find which frames correspond to which interest area per trial. create structure from it.
clear IA_trial
for LL = validation
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
        for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7",
"Video8", "Video9", "Video10", "Video11", "Video12"]
            for AOI = ["NaN", "AOI1", "AOI2"]
               for j = 1:360
                   k =
max((D_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(:,3)==j).*D_trial.(vids).(VARIABLE_Key_Pr
essed).(AOI).(LL)(:,4));

                   for i = 1:0.02*k
                        IA_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL).("Trial"+j)(i,1) =
sum(D_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(:,2)==i &
D_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(:,3)==j);

                   end
%                    if isfield(IA_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL),'Trial'+j)
%                     IA_testtest.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(j,1) =
sum(IA_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL).("Trial"+j));
%
IA_testtest.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(all(~IA_testtest.(vids).(VARIABLE_Key_Pres
sed).(AOI).(LL),2), : ) = [];
%                    end

               end
            end
        end
    end
end
```

```
%% Structure per participant for each trial

clear IA_testtest %needs to be cleared when script is ran more than one time

for LL = validation
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
         for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7",
"Video8", "Video9", "Video10", "Video11", "Video12"]
             for AOI = ["NaN", "AOI1", "AOI2"]
                for j = 1:360

                    try
                     IA_testtest.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(j,1) =
sum(IA_trial.(vids).(VARIABLE_Key_Pressed).(AOI).(LL).("Trial"+j));
                    catch
                     IA_testtest.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(j,1) = 0;
                    end


%IA_testtest.(vids).(VARIABLE_Key_Pressed).(AOI).(LL)(all(~IA_testtest.(vids).(VARIABLE_Key_Pre
ssed).(AOI).(LL),2), : ) = [];
                end
             end
         end
     end
end

clear IA_tottest AOI1_tottot AOI1_dwell
for LL = validation
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
         for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7",
"Video8", "Video9", "Video10", "Video11", "Video12"]

                    IA_tottest.(vids).(VARIABLE_Key_Pressed).(LL) =
[IA_testtest.(vids).(VARIABLE_Key_Pressed).AOI1.(LL)(:,1),
IA_testtest.(vids).(VARIABLE_Key_Pressed).AOI2.(LL)(:,1),
IA_testtest.(vids).(VARIABLE_Key_Pressed).NaN.(LL)(:,1)];
                    AOI1_tottot.(vids).(VARIABLE_Key_Pressed).(LL) =
IA_testtest.(vids).(VARIABLE_Key_Pressed).AOI1.(LL)(:,1)+
IA_testtest.(vids).(VARIABLE_Key_Pressed).AOI2.(LL)(:,1)+
IA_testtest.(vids).(VARIABLE_Key_Pressed).NaN.(LL)(:,1);

                    AOI1_dwell.(vids).(VARIABLE_Key_Pressed).(LL) =
IA_tottest.(vids).(VARIABLE_Key_Pressed).(LL)(:,1)./AOI1_tottot.(vids).(VARIABLE_Key_Pressed).(
LL);

AOI1_dwell.(vids).(VARIABLE_Key_Pressed).(LL)(isnan(AOI1_dwell.(vids).(VARIABLE_Key_Pressed).(L
L))) = [];

         end
     end
end



%% import result file from text
```

```
clear merge

validation = ["Part3", "Part4", "Part5", "Part6", "Part7", "Part8", "Part9", "Part10",
"Part11", "Part12", "Part13", "Part14", "Part15", "Part16", "Part17", "Part18", "Part19",
"Part20", "Part21", "Part22", "Part23", "Part24", "Part25", "Part26"];
%LL = validation;


for LL = validation
%% Setup the Import Options and import the data

    % Assign variables
opts = delimitedTextImportOptions("NumVariables", 7);

% Specify range and delimiter
opts.DataLines = [2, Inf];
opts.Delimiter = "\t";

% Specify column names and types
opts.VariableNames = ["Session_Name_", "Trial_Index_", "video", "VARIABLE_Response",
"VARIABLE_Key_Pressed", "VARIABLE_RT", "list"];
opts.VariableTypes = ["string", "double", "string", "double", "string", "double", "double"];

% Specify variable properties
opts = setvaropts(opts, ["video", "VARIABLE_Key_Pressed", "list"], "EmptyFieldRule", "auto");

% Specify file level properties
opts.ExtraColumnsRule = "ignore";
opts.EmptyLineRule = "read";

% Import the data
% Eigen PC
     folder =
fullfile('C:\Users\Merijn\Desktop\Experiment\Experiment\Results',LL,'Output\RESULTS_FILE.txt');
% TU PC
%     folder = fullfile('C:\Users\mvanniekerk\Downloads\Results',LL,'Output\RESULTS_FILE.txt');

% Import the data
     Rawdata = readtable(folder, opts);

%% Clear temporary variables
clear opts

%% Split for video's showed

     for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
         for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7",
"Video8", "Video9", "Video10", "Video11", "Video12"]
                x_dup = Rawdata.VARIABLE_Response( Rawdata.video == append(vids,".mp4") &
Rawdata.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed );  % &  Rawdata.VARIABLE_Key_Pressed ==
VARIABLE_Key_Pressed  &  Rawdata.AVERAGE_INTEREST_AREAS == AVERAGE_INTEREST_AREAS  &
Rawdata.VIDEO_FRAME_INDEX > 0
                D_out.(vids).(VARIABLE_Key_Pressed).(LL) = x_dup;

                abs.(vids).(VARIABLE_Key_Pressed).(LL) = size(x_dup,1);
                RT_total.(vids).(VARIABLE_Key_Pressed).(LL) = Rawdata.VARIABLE_RT(Rawdata.video
== append(vids,".mp4") &  Rawdata.VARIABLE_Key_Pressed == VARIABLE_Key_Pressed);
```

```
                merge.(LL).(vids).(VARIABLE_Key_Pressed) =
[abs.(vids).(VARIABLE_Key_Pressed).(LL)];

         end
    end


end

%% Or load data from matlab file
load merge

%% Decision outcome plots

%% Prepare decision outcome plots

v = ["V1", "V2", "V3", "V4", "V5", "V6", "V7", "V8", "V9", "V10", "V11", "V12"];

for i = 1:12
    for j = 3:(2+size(validation,2))
        y_{i,j} = merge.("Part" + (j)).("Video" +{i}).Lshift;
    end
end

merge_count = cell2mat(y_);
merge_perc = transpose(merge_count/30);

avg_merge =  mean(merge_count,2);

%% Decision outcome plots
for test = 1 % close if needed
abc = test
close all
fig_outcome_dup = figure(1);

% for dup = 20m, V1,7,2,8
d_up1a = [merge_perc(:,1), merge_perc(:,2)]; % t_on = 4s, t_up = 4,6s
d_up1b = [merge_perc(:,7), merge_perc(:,8)]; % t_on = 6s, t_up = 4,6s
% for d_up = 30m, V3,4,9,10
d_up2a = [merge_perc(:,3), merge_perc(:,4)]; % t_on = 4s, t_up = 4,6s
d_up2b = [merge_perc(:,9), merge_perc(:,10)]; % t_on = 6s, t_up = 4,6s
% for d_up = 40m, V5,6,11,12
d_up3a = [merge_perc(:,5), merge_perc(:,6)]; % t_on = 4s, t_up = 4,6s
d_up3b = [merge_perc(:,11), merge_perc(:,12)]; % t_on = 6s, t_up = 4,6s


subplot(3,2,1)
boxplot(d_up1a, ["4s", "6s"]) %t_on is 4s
title("t_{on} = 4s")
ylabel("d_{upc} = 20m")
ylim([0 1])
grid MINOR
subplot(3,2,2)
boxplot(d_up1b, ["4s", "6s"]) %t_on is 6s
title("t_{on} = 6s")
ylim([0 1])
grid MINOR
```

```
subplot(3,2,3)
boxplot(d_up2a, ["4s", "6s"]) %t_on is 4s
ylabel("d_{upc} = 30m")
ylim([0 1])
grid MINOR
subplot(3,2,4)
boxplot(d_up2b, ["4s", "6s"]) %t_on is 6s
ylim([0 1])
grid MINOR

subplot(3,2,5)
boxplot(d_up3a, ["4s", "6s"]) %t_on is 4s
ylabel("d_{upc} = 40m")
ylim([0 1])
grid MINOR
subplot(3,2,6)
boxplot(d_up3b, ["4s", "6s"]) %t_on is 6s
ylim([0 1])
grid MINOR

%define common title
han=axes(fig_outcome_dup,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Percentage accapted gap over rejected gap','Position', [-0.1, 0.5, 0]);
xlabel(han,'time gap upcoming vehicle [s]');
hold off


%% gap t_upcoming is leading variable

fig_outcome_tup = figure;

% for tup = 4s, V1,3,5; V7,9,11
t_up1a = [merge_perc(:,1), merge_perc(:,3), merge_perc(:,5)]; % t_on = 4s, d_up = 20:40m
t_up1b = [merge_perc(:,7), merge_perc(:,9), merge_perc(:,11)]; % t_on = 6s, d_up = 20:40m

subplot(2,2,1)
boxplot(t_up1a, ["20m", "30m", "40m"]) %t_on is 4s
title("t_{on} = 4s")
ylabel("t_{upc} = 4s")
ylim([0 1])
grid MINOR
subplot(2,2,2)
boxplot(t_up1b, ["20m", "30m", "40m"]) %t_on is 6s
title("t_{on} = 6s")
ylim([0 1])
grid MINOR

% for tup = 6s, V2,4,6; V8,10,12
t_up2a = [merge_perc(:,2), merge_perc(:,4), merge_perc(:,6)]; % t_on = 4s, d_up = 20:40m
t_up2b = [merge_perc(:,8), merge_perc(:,10), merge_perc(:,12)]; % t_on = 6s, d_up = 20:40m

subplot(2,2,3)
boxplot(t_up2a, ["20m", "30m", "40m"]) %t_on is 4s
ylabel("t_{upc} = 6s")
ylim([0 1])
```

```
grid MINOR
subplot(2,2,4)
boxplot(t_up2b, ["20m", "30m", "40m"]) %t_on is 6s
ylim([0 1])
grid MINOR

%define common title
han=axes(fig_outcome_tup,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Percentage accapted gap over rejected gap','Position', [-0.1, 0.5, 0]);
xlabel(han,'distance gap upcoming vehicle [m]');



%% gap t_on-ramp is leading variable

fig_outcome_ton = figure;
% for t_on = 4s , V1,2; V3,4; V5,6
t_on1a = [merge_perc(:,1), merge_perc(:,7)]; % d_up = 20, t_up = 4,6s
t_on1b = [merge_perc(:,3), merge_perc(:,9)]; % d_up = 30, t_up = 4,6s
t_on1c = [merge_perc(:,5), merge_perc(:,11)]; % d_up = 40, t_up = 4,6s

subplot(2,3,1)
boxplot(t_on1a, ["4s", "6s"]) %t_on is 4s
ylabel("t_{upcoming} = 4s")
title("d_{upc} = 20m")
grid MINOR
subplot(2,3,2)
boxplot(t_on1b, ["4s", "6s"]) %t_on is 6s
title("d_{upc} = 30m")
grid MINOR
subplot(2,3,3)
boxplot(t_on1c, ["4s", "6s"]) %t_on is 6s
title("d_{upc} = 40m")
grid MINOR


% for t_on = 6s , V7,8; V9,10; V11,12
t_on2a = [merge_perc(:,2), merge_perc(:,8)]; % d_up = 20, t_up = 4,6s
t_on2b = [merge_perc(:,3), merge_perc(:,10)]; % d_up = 30, t_up = 4,6s
t_on2c = [merge_perc(:,6), merge_perc(:,12)]; % d_up = 40, t_up = 4,6s

subplot(2,3,4)
boxplot(t_on2a, ["4s", "6s"]) %t_on is 4s
ylabel("t_{upcoming} = 6s")
grid MINOR
subplot(2,3,5)
boxplot(t_on2b, ["4s", "6s"]) %t_on is 6s
grid MINOR
subplot(2,3,6)
boxplot(t_on2c, ["4s", "6s"]) %t_on is 6s
grid MINOR

%define common title
han=axes(fig_outcome_ton,'visible','off');
han.Title.Visible='on';
```

```
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Percentage accapted gap over rejected gap','Position', [-0.1, 0.5, 0]);
xlabel(han,'time gap to end of on-ramp [s]');


end
%% linear regression plots decision outcome - not used because incorrect: regression should be
logistic
% time upcoming vehicle is 4 or 6 seconds and time to onramp is 4 seconds

% dup
% d_up = {d_up1a, d_up1b, d_up2a, d_up2b, d_up3a, d_up3b};
%
% fig_outcome_regress_dup = figure
%
% for i = [1 2 3 4 5 6]
% y_dup = [d_up{1,i}(:,1); d_up{1,i}(:,2)];
% x_dup = [4*ones(length(d_up{1,i}(:,1)),1); 6*ones(length(d_up{1,i}(:,2)),1)];
% b1 = x_dup\y_dup;
% %md1{i} = fitlm(x_dup,y_dup)
% subplot(3,2,i)
%
% yCalc1 = b1*x_dup;
% scatter(x_dup,y_dup)
% hold on
% %plot(x,yCalc1)
% % xlabel('Population of state')
% % ylabel('Fatal traffic accidents per state')
% % title('Linear Regression Relation Between Accidents & Population')
% xlim([3 7])
% ylim([0 1.4])
% grid on
%
% X = [ones(length(x_dup),1) x_dup];
% b = X\y_dup;
%
%
% yCalc2 = X*b;
% plot(x_dup,yCalc2,'--')
% %legend('% merge over braking','Slope','Slope & Intercept','Location','NorthEast');
%
% Rsq1 = 1 - sum((y_dup - yCalc1).^2)/sum((y_dup - mean(y_dup)).^2);
% Rsq2 = 1 - sum((y_dup - yCalc2).^2)/sum((y_dup - mean(y_dup)).^2);
% format short
% %txt = ["b_{1}: "+b1, "R^{2}_{slope}: " + Rsq1, "b_{0}: "+b(1,1)+"; b_{1}:"+ b(2,1),
"R^{2}_{slope&intercept}: "+Rsq2];
% txt = ["b_{0}: "+b(1,1)+"; b_{1}:"+ b(2,1), "R^{2}: "+Rsq2];
% text(4,1.22, txt, 'FontSize',6)
%
% end
%
% han=axes(fig_outcome_regress_dup,'visible','off');
% han.Title.Visible='on';
% han.XLabel.Visible='on';
% han.YLabel.Visible='on';
% ylabel(han,'Percentage accapted gap over rejected gap','Position', [-0.1, 0.5, 0]);
% xlabel(han,'time gap to end up-coming vehicle [m]');
```

```
% title("Regression time gap to up-coming vehicle vs % accepted gaps")
%
% % Regression t_upa: time to upcoming vehicle is either 4 or 6 seconds
%
% t_up = {t_up1a, t_up1b, t_up2a, t_up2b};
% fig_outcome_regress_tup = figure
% for i = [1 2 3 4]
% y_tup = [t_up{1,i}(:,1); t_up{1,i}(:,2); t_up{1,i}(:,3)];
% x_tup = [20*ones(length(t_up{1,i}(:,1)),1); 30*ones(length(t_up{1,i}(:,2)),1);
40*ones(length(t_up{1,i}(:,3)),1)];
% b1 = x_tup\y_tup;
%
% subplot(2,2,i)
% yCalc1 = b1*x_tup;
% scatter(x_tup,y_tup)
% hold on
% %plot(x,yCalc1)
% % xlabel('Population of state')
% % ylabel('Fatal traffic accidents per state')
% % title('Linear Regression Relation Between Accidents & Population')
% xlim([0 60])
% ylim([0 1.4])
% grid on
%
% X = [ones(length(x_tup),1) x_tup];
% b = X\y_tup;
%
% yCalc2 = X*b;
% plot(x_tup,yCalc2,'--')
% %legend('% merge over braking','Slope','Slope & Intercept','Location','NorthEast');
%
% Rsq1 = 1 - sum((y_tup - yCalc1).^2)/sum((y_tup - mean(y_tup)).^2);
% Rsq2 = 1 - sum((y_tup - yCalc2).^2)/sum((y_tup - mean(y_tup)).^2);
% format short
% %txt = ["b_{1}: "+b1, "R^{2}_{slope}: " + Rsq1, "b_{0}: "+b(1,1)+"; b_{1}:"+ b(2,1),
"R^{2}_{slope&intercept}: "+Rsq2];
% txt = ["b_{0}: "+b(1,1)+"; b_{1}:"+ b(2,1), "R^{2}: "+Rsq2];
% text(10,1.22, txt, 'FontSize',6)
%
% end
%
% han=axes(fig_outcome_regress_tup,'visible','off');
% han.Title.Visible='on';
% han.XLabel.Visible='on';
% han.YLabel.Visible='on';
% ylabel(han,'Percentage accapted gap over rejected gap','Position', [-0.1, 0.5, 0]);
% xlabel(han,'distance gap to end up-coming vehicle [m]');
% title("Regression distance gap to up-coming vehicle vs % accepted gaps")
%
% % Regression t_on
% t_on = {t_on1a, t_on1b, t_on1c, t_on2a, t_on2b, t_on2c};
%
% fig_outcome_regress3 = figure
% for i = [1 2 3 4 5 6]
% y_ton = [t_on{1,i}(:,1); t_on{1,i}(:,2)];
% x_ton = [4*ones(length(t_on{1,i}(:,1)),1); 6*ones(length(t_on{1,i}(:,2)),1)];
% b1 = x_ton\y_ton;
%
```

```
% subplot(2,3,i)
% yCalc1 = b1*x_ton;
% scatter(x_dup,y_ton)
% hold on
% %plot(x,yCalc1)
%
% xlim([3 7])
% ylim([0 1.4])
% grid on
%
% X = [ones(length(x_ton),1) x_ton];
% b = X\y_ton;
%
% yCalc2 = X*b;
% plot(x_dup,yCalc2,'--')
%
% Rsq1 = 1 - sum((y_ton - yCalc1).^2)/sum((y_ton - mean(y_ton)).^2);
% Rsq2 = 1 - sum((y_ton - yCalc2).^2)/sum((y_ton - mean(y_ton)).^2);
% format short
% % txt = ["b_{1}: "+b1, "R^{2}_{slope}: " + Rsq1,
% txt= ["b_{0}: "+b(1,1)+"; b_{1}:"+ b(2,1), "R^{2}: "+Rsq2];
% text(3.5,1.22, txt, 'FontSize',6)
%
% hold on
%
%
%
% end
%
% han=axes(fig_outcome_regress3,'visible','off');
% han.Title.Visible='on';
% han.XLabel.Visible='on';
% han.YLabel.Visible='on';
% ylabel(han,'Percentage accapted gap over rejected gap','Position', [-0.1, 0.5, 0]);
% xlabel(han,'time gap to end of on-ramp [s]');
% title("Regression time gap to end of on-ramp vs % accepted gaps")

%% Regression: regression table preparations
clear D_all t_on d_up t_up RT_all clear dwell_AOI1_all

Video1 = [4,20,4]; Video2 = [4,20,6]; Video3 = [4,30,4]; Video4 = [4,30,6]; Video5 = [4,40,4];
Video6 = [4,40,6];
Video7 = [6,20,4]; Video8 = [6,20,6]; Video9 = [6,30,4]; Video10 = [6,30,6]; Video11 =
[6,40,4]; Video12 = [6,40,6];

Video =
[Video1;Video2;Video3;Video4;Video5;Video6;Video7;Video8;Video9;Video10;Video11;Video12];

for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
    for i = 3:26
D_all.(vids).(VARIABLE_Key_Pressed){i} =
[D_out.(vids).(VARIABLE_Key_Pressed).("Part"+i),i*ones(size(D_out.(vids).(VARIABLE_Key_Pressed)
.("Part"+i),1),1)];
RT_all.(vids).(VARIABLE_Key_Pressed){i} = RT_total.(vids).(VARIABLE_Key_Pressed).("Part"+i);
```

```
dwell_AOI1_all.(vids).(VARIABLE_Key_Pressed){i} =
AOI1_dwell.(vids).(VARIABLE_Key_Pressed).("Part"+i);

D_all.(vids).(VARIABLE_Key_Pressed){i} = [D_all.(vids).(VARIABLE_Key_Pressed){i-1};
D_all.(vids).(VARIABLE_Key_Pressed){i}];
RT_all.(vids).(VARIABLE_Key_Pressed){i} = [RT_all.(vids).(VARIABLE_Key_Pressed){i-1};
RT_all.(vids).(VARIABLE_Key_Pressed){i}];
dwell_AOI1_all.(vids).(VARIABLE_Key_Pressed){i} =
[dwell_AOI1_all.(vids).(VARIABLE_Key_Pressed){i-1};
dwell_AOI1_all.(vids).(VARIABLE_Key_Pressed){i}];

    end
D_all.(vids).(VARIABLE_Key_Pressed) = D_all.(vids).(VARIABLE_Key_Pressed){26};
RT_all.(vids).(VARIABLE_Key_Pressed) = RT_all.(vids).(VARIABLE_Key_Pressed){26};
dwell_AOI1_all.(vids).(VARIABLE_Key_Pressed) =
dwell_AOI1_all.(vids).(VARIABLE_Key_Pressed){26};

end
D_all.(vids) = [D_all.(vids).Lshift;D_all.(vids).Rshift];
RT_all.(vids) = [RT_all.(vids).Lshift;RT_all.(vids).Rshift];
dwell_AOI1_all.(vids) = [dwell_AOI1_all.(vids).Lshift;dwell_AOI1_all.(vids).Rshift];
end

for i = 1:12
    t_on.("Video"+i) = repmat(Video(i,1),[size(D_all.("Video"+i),1),1]);
    d_up.("Video"+i) = repmat(Video(i,2),[size(D_all.("Video"+i),1),1]);
    t_up.("Video"+i) = repmat(Video(i,3),[size(D_all.("Video"+i),1),1]);
end

D_all_decision =
[D_all.Video1;D_all.Video2;D_all.Video3;D_all.Video4;D_all.Video5;D_all.Video6;D_all.Video7;D_a
ll.Video8;D_all.Video9;D_all.Video10;D_all.Video11;D_all.Video12];
D_all_tot = D_all_decision(:,1);
Part_all_tot = D_all_decision(:,2);

RT_all_tot =
[RT_all.Video1;RT_all.Video2;RT_all.Video3;RT_all.Video4;RT_all.Video5;RT_all.Video6;RT_all.Vid
eo7;RT_all.Video8;RT_all.Video9;RT_all.Video10;RT_all.Video11;RT_all.Video12];

dwell_AOI1_all_tot =
[dwell_AOI1_all.Video1;dwell_AOI1_all.Video2;dwell_AOI1_all.Video3;dwell_AOI1_all.Video4;dwell_
AOI1_all.Video5;dwell_AOI1_all.Video6;dwell_AOI1_all.Video7;dwell_AOI1_all.Video8;dwell_AOI1_al
l.Video9;dwell_AOI1_all.Video10;dwell_AOI1_all.Video11;dwell_AOI1_all.Video12];

t_on_tot =
[t_on.Video1;t_on.Video2;t_on.Video3;t_on.Video4;t_on.Video5;t_on.Video6;t_on.Video7;t_on.Video
8;t_on.Video9;t_on.Video10;t_on.Video11;t_on.Video12];
d_up_tot =
[d_up.Video1;d_up.Video2;d_up.Video3;d_up.Video4;d_up.Video5;d_up.Video6;d_up.Video7;d_up.Video
8;d_up.Video9;d_up.Video10;d_up.Video11;d_up.Video12];
t_up_tot =
[t_up.Video1;t_up.Video2;t_up.Video3;t_up.Video4;t_up.Video5;t_up.Video6;t_up.Video7;t_up.Video
8;t_up.Video9;t_up.Video10;t_up.Video11;t_up.Video12];

y = D_all_tot;
x = [t_on_tot, d_up_tot, t_up_tot];

%% Regression: Regression tables
```

```
clc

tbl =
table(t_on_tot,d_up_tot,t_up_tot,D_all_tot,RT_all_tot,Part_all_tot,dwell_AOI1_all_tot,'Variable
Names',{'Time_gap_onramp','Distance_gap_upcoming_vehicle','Time_gap_upcoming_vehicle',
'Is_gap_accepted','Response_time', 'Participant_no', 'Dwell_to_mirror'});


%% Regression: decision outcome regression

% Binomial
glme_outcome =
fitglme(tbl,'Is_gap_accepted~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+(1|Participant_no)', ...
    'Distribution','Binomial','Link','log','FitMethod','Laplace', ...
    'DummyVarCoding','effects');
disp(glme_outcome)


%% Dwell incl

glme_outcome_int =
fitglme(tbl,'Is_gap_accepted~Time_gap_onramp*Dwell_to_mirror+Distance_gap_upcoming_vehicle*Dwel
l_to_mirror+Time_gap_upcoming_vehicle*Dwell_to_mirror+(1|Participant_no)', ...
    'Distribution','Binomial','Link','log','FitMethod','Laplace', ...
    'DummyVarCoding','effects');
disp(glme_outcome_int)

%plotInteraction(glme_outcome_int,'Time_gap_onramp','Dwell_to_mirror','predictions')

% glme_outcome_incldwell =
fitglme(tbl,'Is_gap_accepted~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+Dwell_to_mirror+(1|Participant_no)', ...
%     'Distribution','Binomial','Link','log','FitMethod','Laplace', ...
%     'DummyVarCoding','effects');
% disp(glme_outcome_incldwell)

%% Regression: RT regression

glme_RT =
fitglme(tbl,'Response_time~Is_gap_accepted+Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_g
ap_upcoming_vehicle+(1|Participant_no)');
disp(glme_RT)


% glme_RT_incldwell =
fitglme(tbl,'Response_time~Is_gap_accepted+Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_g
ap_upcoming_vehicle+Dwell_to_mirror+(1|Participant_no)');
% disp(glme_RT_incldwell)

glme_RT_dwell_int =
fitglme(tbl,'Response_time~Is_gap_accepted+Time_gap_onramp*Dwell_to_mirror+Distance_gap_upcomin
g_vehicle*Dwell_to_mirror+Time_gap_upcoming_vehicle*Dwell_to_mirror+(1|Participant_no)');
disp(glme_RT_dwell_int)


%% Regression: Dwell time regression
```

```
% glme_dwell =
fitglme(tbl,'Dwell_to_mirror~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+(1|Participant_no)', ...
%     'Distribution','normal','Link','log','FitMethod','Laplace', ...
%     'DummyVarCoding','effects');
% disp(glme_dwell)

glme_dwell =
fitglme(tbl,'Dwell_to_mirror~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+(1|Participant_no)');
disp(glme_dwell)

glme_dwell_outcome =
fitglme(tbl,'Dwell_to_mirror~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+Is_gap_accepted+Response_time+(1|Participant_no)');
disp(glme_dwell_outcome)



% %% dwell included
% % glme_dwell_inclRT =
fitglme(tbl,'Dwell_to_mirror~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+Response_time+(1|Participant_no)', ...
% %     'Distribution','normal','Link','log','FitMethod','Laplace', ...
% %     'DummyVarCoding','effects');
% % disp(glme_dwell_inclRT)
%
% glme_dwell_inclRT_dec =
fitglme(tbl,'Dwell_to_mirror~Time_gap_onramp+Distance_gap_upcoming_vehicle+Time_gap_upcoming_ve
hicle+Response_time+Is_gap_accepted+(1|Participant_no)', ...
%     'Distribution','normal','Link','log','FitMethod','Laplace', ...
%     'DummyVarCoding','effects');
% disp(glme_dwell_inclRT_dec)


%% Visualisation plots: Area plot preparation:
%RT Mean per video
clear RT_all

for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
    for i = 3:26
RT_all.(vids).(VARIABLE_Key_Pressed){i} = RT_total.(vids).(VARIABLE_Key_Pressed).("Part"+i);
RT_all.(vids).(VARIABLE_Key_Pressed){i} = [RT_all.(vids).(VARIABLE_Key_Pressed){i-1};
RT_all.(vids).(VARIABLE_Key_Pressed){i}];
% median of all trials per video per choice per participant
med_RT.(vids).(VARIABLE_Key_Pressed).("Part"+i) =
median(RT_total.(vids).(VARIABLE_Key_Pressed).("Part"+i));
    end
RT_all.(vids).(VARIABLE_Key_Pressed) = RT_all.(vids).(VARIABLE_Key_Pressed){26};
end
for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
    %for i = 3:26
Median_RT.(vids).(VARIABLE_Key_Pressed) = median(RT_all.(vids).(VARIABLE_Key_Pressed));
    %end
end
end
```

```
%% Visualisation plots: area plot for sum of all trials
close all

sum_AOI1 = zeros(120,1);
sum_AOI2 = zeros(120,1);
sum_NaN = zeros(120,1);

for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
        for LL = validation

sum_AOI1 = sum_AOI1 + IA_stack.(vids).(VARIABLE_Key_Pressed).AOI1.(LL)(:,1);
sum_AOI2 = sum_AOI2 + IA_stack.(vids).(VARIABLE_Key_Pressed).AOI2.(LL)(:,1);
sum_NaN = sum_NaN + IA_stack.(vids).(VARIABLE_Key_Pressed).NaN.(LL)(:,1);
        end
    end
end

%% Visualisation plots: Dwell time per trial calculation
clear test_AOI1 test_AOI2 test_NaN test

for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
        for LL = validation

if any(isnan(med_RT.(vids).(VARIABLE_Key_Pressed).(LL)), 'all')
test_AOI1 = 0;
test_AOI2 = 0;
test_NaN = 0;

else
test_AOI1 =
IA_stack.(vids).(VARIABLE_Key_Pressed).AOI1.(LL)(1:round(0.02*med_RT.(vids).(VARIABLE_Key_Press
ed).(LL)),1);
test_AOI2 =
IA_stack.(vids).(VARIABLE_Key_Pressed).AOI2.(LL)(1:round(0.02*med_RT.(vids).(VARIABLE_Key_Press
ed).(LL)),1);
test_NaN =
IA_stack.(vids).(VARIABLE_Key_Pressed).NaN.(LL)(1:round(0.02*med_RT.(vids).(VARIABLE_Key_Presse
d).(LL)),1);

end

test.(vids).(VARIABLE_Key_Pressed).(LL) = [sum(test_AOI1, 'all'), sum(test_AOI2, 'all'),
sum(test_NaN, 'all')];
test_total.(vids).(VARIABLE_Key_Pressed).(LL) = sum(test.(vids).(VARIABLE_Key_Pressed).(LL));

dwell_AOI1.(vids).(VARIABLE_Key_Pressed).(LL) =
test.(vids).(VARIABLE_Key_Pressed).(LL)(:,1)/test_total.(vids).(VARIABLE_Key_Pressed).(LL);
dwell_AOI2.(vids).(VARIABLE_Key_Pressed).(LL) =
test.(vids).(VARIABLE_Key_Pressed).(LL)(:,1)/test_total.(vids).(VARIABLE_Key_Pressed).(LL);
dwell_NaN.(vids).(VARIABLE_Key_Pressed).(LL) =
test.(vids).(VARIABLE_Key_Pressed).(LL)(:,1)/test_total.(vids).(VARIABLE_Key_Pressed).(LL);
```

```
% test_sum_AOI2.(vids).(VARIABLE_Key_Pressed).AOI2.(LL) = sum(test_AOI2, 'all');
% test_sum_NaN.(vids).(VARIABLE_Key_Pressed).NaN.(LL) = sum(test_NaN, 'all');


        end
    end
end


%% Visualisation plots: Plot area for all trials

frac_AOI1 = sum_AOI1./(sum_AOI1 + sum_AOI2 + sum_NaN);
frac_AOI2 = sum_AOI2./(sum_AOI1 + sum_AOI2 + sum_NaN);
frac_NaN = sum_NaN./(sum_AOI1 + sum_AOI2 + sum_NaN);

figure
bar([frac_AOI1 frac_AOI2 frac_NaN], 0.5, 'stack')

% Adjust the axis limits
set(gca, 'XTick', 0:20:120)
xticklabels({'1','2','3','4','5','6'})
%yickformat('percentage')

% Add title and axis labels
title('Fixation location AOI')
xlabel('Frame')
ylabel('cumulative AOI')

% Add a legend
legend('Side mirror', 'On-ramp', 'Other')

%% Visualisation plots: Accumulated eye movements per video and decision

validation = ["Part3", "Part4", "Part5", "Part6", "Part7", "Part8", "Part9", "Part10",
"Part11", "Part12", "Part13", "Part14", "Part15", "Part16","Part17", "Part18", "Part19",
"Part20", "Part21", "Part22", "Part23", "Part24", "Part25", "Part26"];

for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
        acc_AOI1.(vids).(VARIABLE_Key_Pressed) = zeros(120,1);
        acc_AOI2.(vids).(VARIABLE_Key_Pressed) = zeros(120,1);
        acc_NaN.(vids).(VARIABLE_Key_Pressed) = zeros(120,1);

        for LL = validation
%LL = validation;

acc_AOI1.(vids).(VARIABLE_Key_Pressed) =  acc_AOI1.(vids).(VARIABLE_Key_Pressed) +
IA_stack.(vids).(VARIABLE_Key_Pressed).AOI1.(LL)(:,1);
acc_AOI2.(vids).(VARIABLE_Key_Pressed) = acc_AOI2.(vids).(VARIABLE_Key_Pressed) +
IA_stack.(vids).(VARIABLE_Key_Pressed).AOI2.(LL)(:,1);
acc_NaN.(vids).(VARIABLE_Key_Pressed) = acc_NaN.(vids).(VARIABLE_Key_Pressed) +
IA_stack.(vids).(VARIABLE_Key_Pressed).NaN.(LL)(:,1);
        end
    end
end

%% Visualisation plots: Area plot per condition
```

```
close all
for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]

perc_AOI1.(vids).(VARIABLE_Key_Pressed) =
acc_AOI1.(vids).(VARIABLE_Key_Pressed)./(acc_AOI1.(vids).(VARIABLE_Key_Pressed) +
acc_AOI2.(vids).(VARIABLE_Key_Pressed) + acc_NaN.(vids).(VARIABLE_Key_Pressed));
perc_AOI2.(vids).(VARIABLE_Key_Pressed) =
acc_AOI2.(vids).(VARIABLE_Key_Pressed)./(acc_AOI1.(vids).(VARIABLE_Key_Pressed) +
acc_AOI2.(vids).(VARIABLE_Key_Pressed) + acc_NaN.(vids).(VARIABLE_Key_Pressed));
perc_NaN.(vids).(VARIABLE_Key_Pressed) =
acc_NaN.(vids).(VARIABLE_Key_Pressed)./(acc_AOI1.(vids).(VARIABLE_Key_Pressed) +
acc_AOI2.(vids).(VARIABLE_Key_Pressed) + acc_NaN.(vids).(VARIABLE_Key_Pressed));


fig = figure;
area(100*[perc_AOI1.(vids).(VARIABLE_Key_Pressed) perc_AOI2.(vids).(VARIABLE_Key_Pressed)
perc_NaN.(vids).(VARIABLE_Key_Pressed)])
hold on

% Median RT per video
xline(0.02*Median_RT.(vids).(VARIABLE_Key_Pressed),'-',{'Median RT'}, 'fontsize', 16)

% Adjust the axis limits
set(gca, 'XTick', 0:20:120, 'FontSize', 16)
xticklabels({'0', '1','2','3','4','5','6'})
ylim([0 100])
xlim([0 120])
ytickformat('percentage')

if VARIABLE_Key_Pressed == "Lshift"
decision = "accepted gap";
else
    decision = "rejected gap";
end
% Add title and axis labels
ttl = title('Fixation location to AOI '+ (vids)+ ' ' + (decision))
ttl.FontSize = 14;
xlbl = xlabel('Time [s]')
xlbl.FontSize = 16;
ylbl = ylabel('% fixated on AOI')
ylbl.FontSize = 16;

% Add a legend
lgd = legend('Side mirror', 'On-ramp', 'Other')
lgd.FontSize = 16;

saveas(gcf,sprintf('%s.jpg',get(get(gca,'title'),'string')))

    end
end
%%
close all


% %% ANOVA & Analysis
%
```

```
% [p,tbl,stats] = anova1([perc_AOI1.Video1.Lshift, perc_AOI1.Video2.Lshift,
perc_AOI1.Video3.Lshift, perc_AOI1.Video4.Lshift, perc_AOI1.Video5.Lshift,
perc_AOI1.Video6.Lshift, perc_AOI1.Video7.Lshift, perc_AOI1.Video8.Lshift,
perc_AOI1.Video9.Lshift, perc_AOI1.Video10.Lshift, perc_AOI1.Video11.Lshift,
perc_AOI1.Video12.Lshift, perc_AOI1.Video1.Rshift, perc_AOI1.Video2.Rshift,
perc_AOI1.Video3.Rshift, perc_AOI1.Video4.Rshift, perc_AOI1.Video5.Rshift,
perc_AOI1.Video6.Rshift, perc_AOI1.Video7.Rshift, perc_AOI1.Video8.Rshift,
perc_AOI1.Video9.Rshift, perc_AOI1.Video10.Rshift, perc_AOI1.Video11.Rshift,
perc_AOI1.Video12.Rshift])
%
% Fstat = tbl{2,5}
% results = multcompare(stats);

%%
close all


%% Boxplots: dwell boxplots
clear dwell

for AOI = ["wind-screen"]

disp("you just ran % dwell time plots to the "+AOI)


% plot prep

for vids = ["Video1", "Video2", "Video3", "Video4", "Video5", "Video6", "Video7", "Video8",
"Video9", "Video10", "Video11", "Video12"]
    for VARIABLE_Key_Pressed = ["Lshift", "Rshift"]
        for i = 3:26
        dwell.(vids).(VARIABLE_Key_Pressed){i} =
AOI1_dwell.(vids).(VARIABLE_Key_Pressed).("Part"+i);
        dwell.(vids).(VARIABLE_Key_Pressed){i} = [dwell.(vids).(VARIABLE_Key_Pressed){i-1};
dwell.(vids).(VARIABLE_Key_Pressed){i}];
        end
    dwell.(vids).(VARIABLE_Key_Pressed) = dwell.(vids).(VARIABLE_Key_Pressed){26};
end
end


%% Mirror figures d_up-coming as leading left variable; d_up-coming [s] on x-axis: Video
1,3,5,7,9,11 = 4s | Video 2,4,6,8,10,12 = 6s
close all

t_up = [4,6];

for dec = ["Lshift", "Rshift"]
dwell_d_up1a.(dec) = [dwell.Video1.(dec)(:,1); dwell.Video2.(dec)(:,1)];
dwell_d_up1b.(dec) = [dwell.Video7.(dec)(:,1); dwell.Video8.(dec)(:,1)];
dwell_d_up2a.(dec) = [dwell.Video3.(dec)(:,1); dwell.Video4.(dec)(:,1)];
dwell_d_up2b.(dec) = [dwell.Video9.(dec)(:,1); dwell.Video10.(dec)(:,1)];
dwell_d_up3a.(dec) = [dwell.Video5.(dec)(:,1); dwell.Video6.(dec)(:,1)];
dwell_d_up3b.(dec) = [dwell.Video11.(dec)(:,1); dwell.Video12.(dec)(:,1)];

dwell_grp_dup1a.(dec) = [ones(size(dwell.Video1.(dec)(:,1)));
2.*ones(size(dwell.Video2.(dec)(:,1)))];
```

```
dwell_grp_dup1b.(dec) = [ones(size(dwell.Video7.(dec)(:,1)));
2.*ones(size(dwell.Video8.(dec)(:,1)))];
dwell_grp_dup2a.(dec) = [ones(size(dwell.Video3.(dec)(:,1)));
2.*ones(size(dwell.Video4.(dec)(:,1)))];
dwell_grp_dup2b.(dec) = [ones(size(dwell.Video9.(dec)(:,1)));
2.*ones(size(dwell.Video10.(dec)(:,1)))];
dwell_grp_dup3a.(dec) = [ones(size(dwell.Video5.(dec)(:,1)));
2.*ones(size(dwell.Video6.(dec)(:,1)))];
dwell_grp_dup3b.(dec) = [ones(size(dwell.Video11.(dec)(:,1)));
2.*ones(size(dwell.Video12.(dec)(:,1)))];
end
%

% LSHIFT decisions
% t_up = 4s
fig_LSHIFT_dup = figure;

%t_up = 4s; t_on = 4s
subplot(3,2,1)
boxplot(100*[dwell_d_up1a.Lshift], dwell_grp_dup1a.Lshift, 'Labels', t_up)
title("t_{on} = 4s")
ylabel("d_{up} = 20m")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 4s; t_on = 6s
subplot(3,2,2)
boxplot(100*[dwell_d_up1b.Lshift], dwell_grp_dup1b.Lshift, 'Labels', t_up)
title("t_{on} = 6s")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 4s
subplot(3,2,3)
boxplot(100*[dwell_d_up2a.Lshift], dwell_grp_dup2a.Lshift, 'Labels', t_up)
ylabel("d_{up} = 30m")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 6s
subplot(3,2,4)
boxplot(100*[dwell_d_up2b.Lshift], dwell_grp_dup2b.Lshift, 'Labels', t_up)
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 4s
subplot(3,2,5)
boxplot(100*[dwell_d_up3a.Lshift], dwell_grp_dup3a.Lshift, 'Labels', t_up)
ylabel("d_{up} = 40m")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 6s
```

```
subplot(3,2,6)
boxplot(100*[dwell_d_up3b.Lshift], dwell_grp_dup3b.Lshift, 'Labels', t_up)
grid MINOR
ylim([0 100])
ytickformat('percentage')

%define common title
han=axes(fig_LSHIFT_dup,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Dwell time [%]','Position', [-0.1, 0.5, 0]);
xlabel(han,'Time gap to upcoming vehicle [s]');
title(han, 'Accepted gap')


% Rshift decisions
% t_up = 4s
fig_RSHIFT_dup = figure;

%t_up = 4s; t_on = 4s
subplot(3,2,1)
boxplot(100*[dwell_d_up1a.Rshift], dwell_grp_dup1a.Rshift, 'Labels', t_up)
title("t_{on} = 4s")
ylabel("d_{up} = 20m")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 4s; t_on = 6s
subplot(3,2,2)
boxplot(100*[dwell_d_up1b.Rshift], dwell_grp_dup1b.Rshift, 'Labels', t_up)
title("t_{on} = 6s")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 4s
subplot(3,2,3)
boxplot(100*[dwell_d_up2a.Rshift], dwell_grp_dup2a.Rshift, 'Labels', t_up)
ylabel("d_{up} = 30m")
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 6s
subplot(3,2,4)
boxplot(100*[dwell_d_up2b.Rshift], dwell_grp_dup2b.Rshift, 'Labels', t_up)
grid MINOR
ylim([0 100])
ytickformat('percentage')

%t_up = 6s; t_on = 4s
subplot(3,2,5)
boxplot(100*[dwell_d_up3a.Rshift], dwell_grp_dup3a.Rshift, 'Labels', t_up)
ylabel("d_{up} = 40m")
grid MINOR
ylim([0 100])
```

```
ytickformat('percentage')

%t_up = 6s; t_on = 6s
subplot(3,2,6)
boxplot(100*[dwell_d_up3b.Rshift], dwell_grp_dup3b.Rshift, 'Labels', t_up)
grid MINOR
ylim([0 100])
ytickformat('percentage')

%define common title
han=axes(fig_RSHIFT_dup,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Dwell time [%]','Position', [-0.1, 0.5, 0]);
xlabel(han,'Time gap to upcoming vehicle [s]');
title(han, 'Rejected gap')
end

%% Boxplots: RT figures d_up-coming as leading left variable; d_up-coming [s] on x-axis: Video
1,3,5,7,9,11 = 4s | Video 2,4,6,8,10,12 = 6s
close all

t_up = [4,6];

for dec = ["Lshift", "Rshift"]
RT_d_up1a.(dec) = [RT_all.Video1.(dec)(:,1); RT_all.Video2.(dec)(:,1)];
RT_d_up1b.(dec) = [RT_all.Video7.(dec)(:,1); RT_all.Video8.(dec)(:,1)];
RT_d_up2a.(dec) = [RT_all.Video3.(dec)(:,1); RT_all.Video4.(dec)(:,1)];
RT_d_up2b.(dec) = [RT_all.Video9.(dec)(:,1); RT_all.Video10.(dec)(:,1)];
RT_d_up3a.(dec) = [RT_all.Video5.(dec)(:,1); RT_all.Video6.(dec)(:,1)];
RT_d_up3b.(dec) = [RT_all.Video11.(dec)(:,1); RT_all.Video12.(dec)(:,1)];

RT_grp_dup1a.(dec) = [ones(size(RT_all.Video1.(dec)(:,1)));
2.*ones(size(RT_all.Video2.(dec)(:,1)))];
RT_grp_dup1b.(dec) = [ones(size(RT_all.Video7.(dec)(:,1)));
2.*ones(size(RT_all.Video8.(dec)(:,1)))];
RT_grp_dup2a.(dec) = [ones(size(RT_all.Video3.(dec)(:,1)));
2.*ones(size(RT_all.Video4.(dec)(:,1)))];
RT_grp_dup2b.(dec) = [ones(size(RT_all.Video9.(dec)(:,1)));
2.*ones(size(RT_all.Video10.(dec)(:,1)))];
RT_grp_dup3a.(dec) = [ones(size(RT_all.Video5.(dec)(:,1)));
2.*ones(size(RT_all.Video6.(dec)(:,1)))];
RT_grp_dup3b.(dec) = [ones(size(RT_all.Video11.(dec)(:,1)));
2.*ones(size(RT_all.Video12.(dec)(:,1)))];
%

fig_RT_dup.(dec) = figure

%t_up = 4s; t_on = 4s
subplot(3,2,1)
boxplot(RT_d_up1a.(dec), RT_grp_dup1a.(dec), 'Labels', t_up)
ylabel("d_{up} = 20m")
grid MINOR
ylim([0 6000])

%t_up = 4s; t_on = 6s
subplot(3,2,2)
```

```
boxplot(RT_d_up1b.(dec), RT_grp_dup1b.(dec), 'Labels', t_up)
grid MINOR
ylim([0 6000])

%t_up = 6s; t_on = 4s
subplot(3,2,3)
boxplot(RT_d_up2a.(dec), RT_grp_dup2a.(dec), 'Labels', t_up)
ylabel("d_{up} = 30m")
grid MINOR
ylim([0 6000])

%t_up = 6s; t_on = 6s
subplot(3,2,4)
boxplot(RT_d_up2b.Lshift, RT_grp_dup2b.Lshift, 'Labels', t_up)
grid MINOR
ylim([0 6000])

%t_up = 6s; t_on = 4s
subplot(3,2,5)
boxplot(RT_d_up3a.(dec), RT_grp_dup3a.(dec), 'Labels', t_up)
ylabel("d_{up} = 40m")
grid MINOR
ylim([0 6000])

%t_up = 6s; t_on = 6s
subplot(3,2,6)
boxplot(RT_d_up3b.(dec), RT_grp_dup3b.(dec), 'Labels', t_up)
grid MINOR
ylim([0 6000])

%define common title
han=axes(fig_RT_dup.(dec),'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'RT [ms]','Position', [-0.1, 0.5, 0]);
xlabel(han,'Time gap to upcoming vehicle [s]');

if dec == "Lshift"
title(han, 'Accepted gap')
else
    title(han, 'Rejected gap')
end
end

%% Boxplots: single dwell time plot (one condition)
close all
fig_report_Dwell = figure
subplot(1,2,1)
boxplot(100*[dwell_d_up2b.Lshift], dwell_grp_dup2b.Lshift, 'Labels', t_up)
grid MINOR
ylim([0 100])
ytickformat('percentage')
set(gca, 'FontSize',16)
title('Accepted gap', 'FontSize',16)

subplot(1,2,2)
boxplot(100*[dwell_d_up2b.Rshift], dwell_grp_dup2b.Rshift, 'Labels', t_up)
```

```
grid MINOR
ylim([0 100])
ytickformat('percentage')
set(gca, 'FontSize',16)
title('Rejected gap', 'FontSize',16)

han=axes(fig_report_Dwell,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Dwell time [%]','Position', [-0.1, 0.5, 0], 'FontSize',16);
%xlabel(han,'Time gap to upcoming vehicle [s]', 'FontSize',16);
%title(han, 'Dwell time to side mirror', 'Position', [0.5,1.05,0], 'FontSize',16)

%% Boxplots: single decision outcome plot (1 condition)
close all

fig_report_outcome = figure
boxplot(100*d_up2b, ["4", "6"]) %t_on is 6s
ylim([0 100])
grid MINOR
ytickformat('percentage')
set(gca, 'FontSize',16)
ylabel('Accapted gap over rejected gap [%]', 'FontSize', 16);
%xlabel('time gap upcoming vehicle [s]');
%title('Percentage accepted over rejected gap')

%% use for report RT
t_up = [4,6];

for dec = ["Lshift", "Rshift"]
RT_d_up1a_fig.(dec) = [RT_all.Video1.(dec)(:,1); RT_all.Video2.(dec)(:,1)];
RT_d_up1b_fig.(dec) = [RT_all.Video7.(dec)(:,1); RT_all.Video8.(dec)(:,1)];
RT_d_up2a_fig.(dec) = [RT_all.Video3.(dec)(:,1); RT_all.Video4.(dec)(:,1)];
RT_d_up2b_fig.(dec) = [RT_all.Video9.(dec)(:,1); RT_all.Video10.(dec)(:,1)];
RT_d_up3a_fig.(dec) = [RT_all.Video5.(dec)(:,1); RT_all.Video6.(dec)(:,1)];
RT_d_up3b_fig.(dec) = [RT_all.Video11.(dec)(:,1); RT_all.Video12.(dec)(:,1)];

RT_grp_dup1a_fig.(dec) = [ones(size(RT_all.Video1.(dec)(:,1)));
2.*ones(size(RT_all.Video2.(dec)(:,1)))];
RT_grp_dup1b_fig.(dec) = [ones(size(RT_all.Video7.(dec)(:,1)));
2.*ones(size(RT_all.Video8.(dec)(:,1)))];
RT_grp_dup2a_fig.(dec) = [ones(size(RT_all.Video3.(dec)(:,1)));
2.*ones(size(RT_all.Video4.(dec)(:,1)))];
RT_grp_dup2b_fig.(dec) = [ones(size(RT_all.Video9.(dec)(:,1)));
2.*ones(size(RT_all.Video10.(dec)(:,1)))];
RT_grp_dup3a_fig.(dec) = [ones(size(RT_all.Video5.(dec)(:,1)));
2.*ones(size(RT_all.Video6.(dec)(:,1)))];
RT_grp_dup3b_fig.(dec) = [ones(size(RT_all.Video11.(dec)(:,1)));
2.*ones(size(RT_all.Video12.(dec)(:,1)))];
%
end

close all
fig_report_RT = figure
subplot(1,2,1)
boxplot(0.001*[RT_d_up2b_fig.Lshift], RT_grp_dup2b_fig.Lshift, 'Labels', t_up)
grid MINOR
```

```
ylim([0 6])
set(gca,'FontSize', 16)
title('Accepted gap', 'FontSize', 16)

subplot(1,2,2)
boxplot(0.001*[RT_d_up2b_fig.Rshift], RT_grp_dup2b_fig.Rshift, 'Labels', t_up)
grid MINOR
ylim([0 6])
set(gca,'FontSize', 16)
title('Rejected gap', 'FontSize', 16)

han=axes(fig_report_RT,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Response time [s]','Position', [-0.1, 0.5, 0], 'FontSize', 16);
%xlabel(han,'Time gap to upcoming vehicle [s]');
%title(han, 'Response time', 'Position', [0.5,1.05,0])
```