ITE

Information Through Elements

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Future Mobility Squad
DPB390 Final Bachelor Project

Prologue

This Final Bachelor Project has been made within the Future Mobility Squad in the Industrial Design department of the Eindhoven University of Technology. This squad aims "to tackle major mobility challenges through applying novel technologies, such as sensing, big, data, internet of things and ubiquitous computing" (Canvas LMS., 2021) with a focus on automated cars. Not only does the squad look at these novel technologies, but also at novel interactions and interactive materials. These can for instance be implemented in car interiors.

The Future Mobility Squad was my second squad preference for my Final Bachelor Project. My first preference was Play and Learn with a focus on a specific subject which was designing for Mental Health. It was interesting to me during times of COVID-19. After the kick-off meeting in the Future Mobility Squad and choosing my topic however, I can state I am glad I got to join this squad.

Autonomous cars have been of interest to me before even starting the study of Industrial Design. During the bachelor I have developed my vision in which I state that I vision a future in which technology has a positive impact on the daily life. I give the example that one has a smart home, in which the alarm goes off, screens go up, one wakes up and after a while the coffee is ready, just when you are ready. An automated car which is ready to go at the time you need to go can belong to this morning ritual and can make sure this person starts his/her day better.

The sketched scenario seems like a scenario from a futuristic movie to lots of people. But knowing it is already possible with current technologies I am eager to make this known and integrate this into my designs. That is why I state I am glad to be able to design for this squad.

Moreover, the topic I design for, which is gaining users trust in automated vehicles, contributes to this as well. In my vision I mention that I strive towards knowledgeable design while creating awareness of the interaction with a focus on its consequences. In this squad, especially in this topic there are various opportunities to design for gaining the required trust with these aspects in mind. This is an additional reason this squad suits me for my Final Bachelor Project.

Summary

It is very likely that in the future humanity will use and drive around in fully autonomous cars. Before we get to this point in the future, we will need to go through a transition in which we must learn to trust automated cars. That will be a challenge.

Various studies show that current trust in autonomous cars is low. To improve trust, other studies have shown that users must be provided with a continuous flow of personalized information.

ITE is designed as a new way to improve trust in automated cars (automated cars of level 3 / 4). The system provides the user with a continuous flow of personalized information through elements integrated in the dashboard of the car. Via the settings of the car, or the application that comes with the car, the user can set their preferences in showing the amount of information that will support trust in the car.

Via literature research all information was found that supports trust in automated cars. By analyzing this data using an affinity diagram it was concluded there are 3 types of information: *Future Actions* of the car, its *Situational Awareness* and the car's *Warnings & Uncertainty*.

In brainstorm sessions participants were asked to link information that would be intuitive with various aspects of the elements of the ITE system. Among other aspects, it was asked to link information to change in height, change in place, turning and color of the elements.

Thus, ITE continuously provides the user with a continuous flow of personalized information, all to provide the right amount of information for each individual in each different situation.

Figure 1: The ITE System (Tesla's Model 3 Interior, n.d.)

Content

Introduction

This design report is about the process of the ITE System, a design made as Final Bachelor Project for the study of Industrial Design. ITE has been made in the Future Mobility Squad in the Industrial Design department of the Eindhoven University of Technology. The report starts with an introduction to the topic and relevant literature. In the subsequent section you can read about the design process including the problem substantiating the topic and the design iterations. Next, a description of the final design is given after which I discuss the design and design process. The report ends with an overall conclusion on the design and the design process.

One of the topics of the past semester, to either do research in or to design for, was "Trust & Automated Vehicles". It was specified in "make users trust the automated vehicle or make other road users trust the automated vehicle" (Future Mobility Squad, 2021). Making users trust the automated vehicle took my interest and thus became the topic I designed for.

The topic itself is rather broad. Vehicles include many forms of transport, among which public transport and cars. To specify the topic, I chose to focus on automated cars. To explore the field and create an even more specific design goal than "make users trust the automated car", research has been done on what causes people to not trust automated cars. This is discussed in the *literature* section following this introduction. Moreover, I explored what has been researched in this field including solutions to this problem.

This eventually led to the design goal which the ITE system is designed for:

Create a design that is used inside an automated car that continuously gives the driver personal information, such that this car gains the driver's trust in times human drivers are transitioning from manual driving to using autonomous cars.

This design goal includes several terms such as *continuously* and *personally*, which can be rather confusing. Furthermore, it is very specific in what the design must do to support trust. Throughout the report it will become clear why this goal is as specific as it is, and why these terms are included in the design goal.

As mentioned, literature influenced the specificity of the design goal. This will be discussed in the next section.

Literature

In this section an overview will be given of several subtopics within the main topic of trust in automated cars. It starts with numbers from various studies indicating current trust in self-driving cars including the reasons why there is lower trust in this type of cars. In addition, theory about trust in automation is mentioned after which related work and studies in this field are discussed.

Numbers & Causations

Nowadays people will probably have heard of some kind of automation in cars. However, I assume a minority has ever been inside a car that has automated features. Nevertheless, there are still studies that investigated trust in autonomous cars based on the current knowledge and feelings towards self-driving cars that the respondents or participants have. The results are not very positive. A poll among American consumers from Partners for Automated Vehicle Education (PAVE) showed among other things that "about 48 percent said they would never get in a taxi or ride-sharing vehicle that was self-driving" and "another 20 percent thinks autonomous vehicles will never be safe "(Hawkins, 2020). PAVE concludes that more people will trust self-driving cars when more of them hit the road.

I personally believe that once we have fully autonomous cars, the large part of humanity will trust them and use it as they use their cars nowadays. However, it is required to start building trust in the transition towards that. Especially since "a study conducted by Advocates for Highway and Auto Safety (Advocates) shows that 64 percent of American consumers have concerns about sharing the road with driverless cars" (Kirkpatrick, 2019). Moreover, in a poll from SurveyMonkey (n.d.) it was found that 65% of respondents were not likely to purchase a self-driving car, and only 6% responded that they will extremely likely buy a self-driving car.

The reasons for this distrust can be found in different explanations. PAVE mentions that their results, the skepticism and distrust, stem from ignorance and lack of experience. This can also be concluded from their poll because it also showed that more familiarity and approval with advanced driver assistance systems (ADAS) led to more positive attitude towards self-driving cars. Brookings however, found that the problem is with technology in general. For instance, 26 percent of the Americans does not trust AI to do work, including driving (West & Karsten, 2015).

Trust in automation

Since automation - luckily - cannot only be found inside cars but has been here for many years in other machinery, researchers have studied trust in automation and came up with various theoretical models. The fact that trust is not binary, influenced these models. Binary trust would mean that there is either trust or no trust at all. However, it is rather seen as a continuum. Muir's model (1994) leans on expectation which are assessed through perception of three factors which are *predictability*, *dependability*, and *faith*. Both dependability and faith are based on, and can be changed by experience. Therefore, to get users inside automated cars, we need to address the predictability which "may also vary depending on the displayed information" (Manchon et al., 2020).

Lee & See (2004) argue that trust in automation evolves in a dynamic loop underpinned by the operators' *internal* factors such as cultural differences, *external* constraints such as time pressure and the *appropriateness of trust in automation*. Finally, the experience with the *performance and feedback* of the automation will impact the trust (Manchon et al., 2020). Thus, especially in the transition towards fully self-driving cars, feedback should be provided to keep the user trust the automation, since the users do not have experience with the performance of these cars yet.

Based on Lee an See's previous work and new empirical research from literature, Hoff and Bashir (2014) came with a new model of trust in automation. They argue three layers of variability in trust: *dispositional*, *situational*, and *learned* which is divided in *initial learned trust* which can evolve into *dynamic learned trust* during the operators' interaction with the automation. This dynamic learned trust can be influenced by the design features of the automation. These design features were important to keep in mind in the process towards the design of ITE. Studies showed that design features like the appearance, the ease-of-use, communication style, transparency, feedback, and the level of control of the operators are important (Manchon et al., 2020). These studies will be discussed in the following section.

Trust in automated cars

As we can conclude from the theoretical trust models, to build trust in automation, information and feedback must be provided to the user in the right design features. Three workers from Intel also stated this in a pamphlet about automated vehicle adoption (Weast et al., 2016). They also state that communication "must be flexible, providing more or less information based on preferences and context". This is supported in an article by Olaverri-Monreal (2020) in which she states that enhancing the driver's situational awareness, which can be achieved through a continuously flow of information, can promote acceptance of automation. Acceptance is a step towards trusting automated cars. As can be seen, both the pamphlet and article have had their influence on the specificity of the design goal. *Personally* does come from the pamphlet of Weast et al. *Continuously* is based on the article by Olaverri-Monreal.

What the right design features are to communicate information has been investigated in a various number of studies. Several researchers conducted experiments with showing different kinds of information and different ways of showing this information in automated cars.

Wintersberger et al. (2017) for instance found that augmented reality, to display the position of the surrounding vehicles during a foggy drive in a simulator, increased driver's overall trust. Koo et al. (2014) experimented with showing three different types of information (*How* the automated car will perform, the reasons *Why* it will perform these actions, and a combination of the two). Participants were put in an auto-braking function simulator and were shown different messages prior to the autonomous actions of the car. Only showing *why* it will perform had the highest level of trust among participants while showing *how + why* had the lowest trust probably due to too high cognitive for the user. In a study conducted by Du et al. (2019) it was found that explanations given by an automated car before it performed a maneuver, in situations such as priority vehicle approaching or obstructed lane, were associated with higher trust, albeit in a verbal manner. In another simulation study which was done by Beller, Heesen and Vollrath (2013) a trust drop could be prevented by showing the automated cars' uncertainty with a binary pictogram which thus showed that the car is either uncertain or not. Helldin (2013) found the same result, but with a seven-point uncertainty gauge instead of a binary pictogram. "Dynamically displaying the AV uncertainty may therefore benefit drivers' trust calibration process" (Manchon et al., 2020). It is important to keep this in mind in the process towards the design which would have to support trust. A trust drop in early stages of trust development in an automated car could have the consequence that the user does not even want to trust the car anymore.

This literature review has been done in an early stage of the design process. It helped in specifying the design goal. Moreover, it scientifically argues for choosing the types of information that ITE provides to the user. The creation of the types of information, and the way that this information is displayed, is motivated by the results of other steps towards the final design. These steps are described in the next section *Process*.

Design Process

In this section the process towards the final design is described. It starts with an elaboration on the design goal, after which the design phases are described including the design iterations.

Design Goal

Recent years we have seen many developments in autonomous cars. Nowadays, we even have cars on the road that are partly automated, for instance Tesla Autopilot (Autopilot, n.d.). For many it is not the question if, but rather when humanity will make use of fully autonomous cars. When that time arrives, I believe humanity went through a transition in which we have become familiar with the technology and eventually trust the cars as well.

We are at the beginning of this transition, but numbers show that people do not really trust autonomous cars (Hawkins, 2020. Kirkpatrick, 2019). Yet. During this transition it is required to gain user's trust in automated cars. As literature shows, this can be done by continuously providing the right amount of information to the user in such a way that it supports the development of trust in the automated car. Since the user is sitting inside the car when in use, the most reasonable place to do so is inside the car. The design goal can therefore be stated as followed:

Create a design that is used inside an automated car that continuously gives the driver personal information, such that this car gains the driver's trust in times human drivers are transitioning from manual driving to using autonomous cars.

Design Phases

Introduction, brainstorm & early ideas.

At the start of the project the topics, to either design for or do research in were introduced. Several topics had my interest. To choose a topic, a huge mind map was made with some early ideas belonging to the different topics of interest. From this huge mind map, a selection of ideas that all suit "make the user trust the automated vehicle" was chosen.

These early ideas supported the creation of two ideas. One of the ideas included an experience inside an automated car. By using VR, users would experience how it feels to be inside a riding automated car, while creating a feeling of safety for users. This feeling would be created because the users are experiencing it in VR instead of on the real road. The second idea included a design in or on top of the interior that would support people to get in an autonomous car and support their trust in the car. The way the design would do so was not yet defined at that time. Two mood boards including pictures that represented the ideas were made to communicate the ideas (figure 2 & 3). More passion towards this second idea was felt, so it was decided to proceed with that idea.

Figure 2: Moodboard VR Idea

Figure 3: Moodboard Interior Idea

In the same week of the creation of these two ideas, a brainstorm session was held together with a friend to stimulate each other's thoughts. This brainstorm session led to new insights and design inspiration. The Audi OLED "the swarm" lighting system was, among other things, mentioned in this brainstorm session (figure 4). The in 2013 released video shows "the swarm" lights as a new lighting concept in which an OLED display covers the complete back of the car and the dynamic movement of the "swarm" can give additional information about the behavior of the car to other traffic (Audi Australia, 2013).

Figure 4: Audi OLED "the swarm" (Audi Australia, 2013)

Another design inspiration was the BMW VISION NEXT 100 concept car. Before the start of the project I was already familiar with this car. This concept car immediately came to my mind at the start of the project. This autonomous car provides additional information to the user by use of the Alive Geometry (figure 5), an analogue display on the dashboard showing information in an intuitive way (BMW Group, n.d.). Moreover, in this car the "driver is in constant communication with the vehicle in an intuitive and natural way". For instance, by use of The Digital Companion (figure 5) which provides the user with subtle, intuitive assistance and the right recommendations to meet the user's needs (BMW Group, n.d.).

Figure 5: Alive Geometry (left) & The Digital Companion (right) (BMW Group, n.d.)

The Alive Geometry from the BMW concept car and the movement of the Audi swarm lights are very interesting and intuitive to me. I started to think about how to combine these concepts in a single design communicating information in an intuitive and natural manner. These concepts (cars) had major influence on the first design concepts.

Literature & Company

To narrow down the scope for the final design, a company was searched to design for/with. Designing for a company, even though it might be imaginary, narrows down the scope for the project. A various number of aspects of a design can be excluded because they do not suit the company. Reversing it, other design aspects do suit the company and therefore can be integrated in the design. Since the BMW VISION Next 100 concept car was an inspiration, the choice for a company was made easily. BMW has been kept in mind during the design process.

Moreover, as stated earlier, to specify the design goal, literature research has been done. A review of this literature can be read in the Introduction. The research and theoretical models discussed there led to the decision of providing the user with information in order to support trust. However, the question remained what information the user must be provided with that supports their trust in an automated car. A way to find this out was asking this question in a survey. However, people cannot imagine what it would be like to sit inside an automated car that the final design would be made for. Therefore, they cannot give very useful answers to this question. In a search for an answer, additional literature research was done to find studies that provide an answer to that question. Several studies were found in which experiments were done with different kinds of information that is provided in different ways.

To analyze all different results of these studies, an affinity diagram was made(figure 6). In this affinity diagram the provided information that generated trust was grouped. This resulted in three different types of information the car can provide to the user to gain and maintain trust. These types are *Warnings & Uncertainty/Take Over Request (TOR)*, *Future Actions*, and *Situational Awareness*.

Figure 6: Information affinity diagram

Using the Audi swarm lights as inspiration for providing the information, a table was made that shows how similar swarm lights inside the car would provide the types of information in specific situations. For example, how uncertainty would be shown in the *Warnings & Uncertainty* category, how taking a turn would be shown in *Future Actions* and how other traffic would be shown in *Situational Awareness*. A concept was made in which a display on the dashboard would show this swarm lighting and thus the information to the user. Because it was stated in the design goal that the information should be personal, in this concept the user could control the amount of information. This idea emerged in the first design concepts, which is described in the next section.

First design concept & Midterm demo day

After the first literature research, first design ideas were made that would show information to the user. With both the design inspiration and company in mind a few sketches were made (figure 7). In these sketches an addition to the dashboard can be seen, as well as a central slider. The display would show the information, while the user sets the right amount of information with use of the slider. This slider would not only be a slider to set the right amount of information but would also operate as a communication tool to gain more trust.

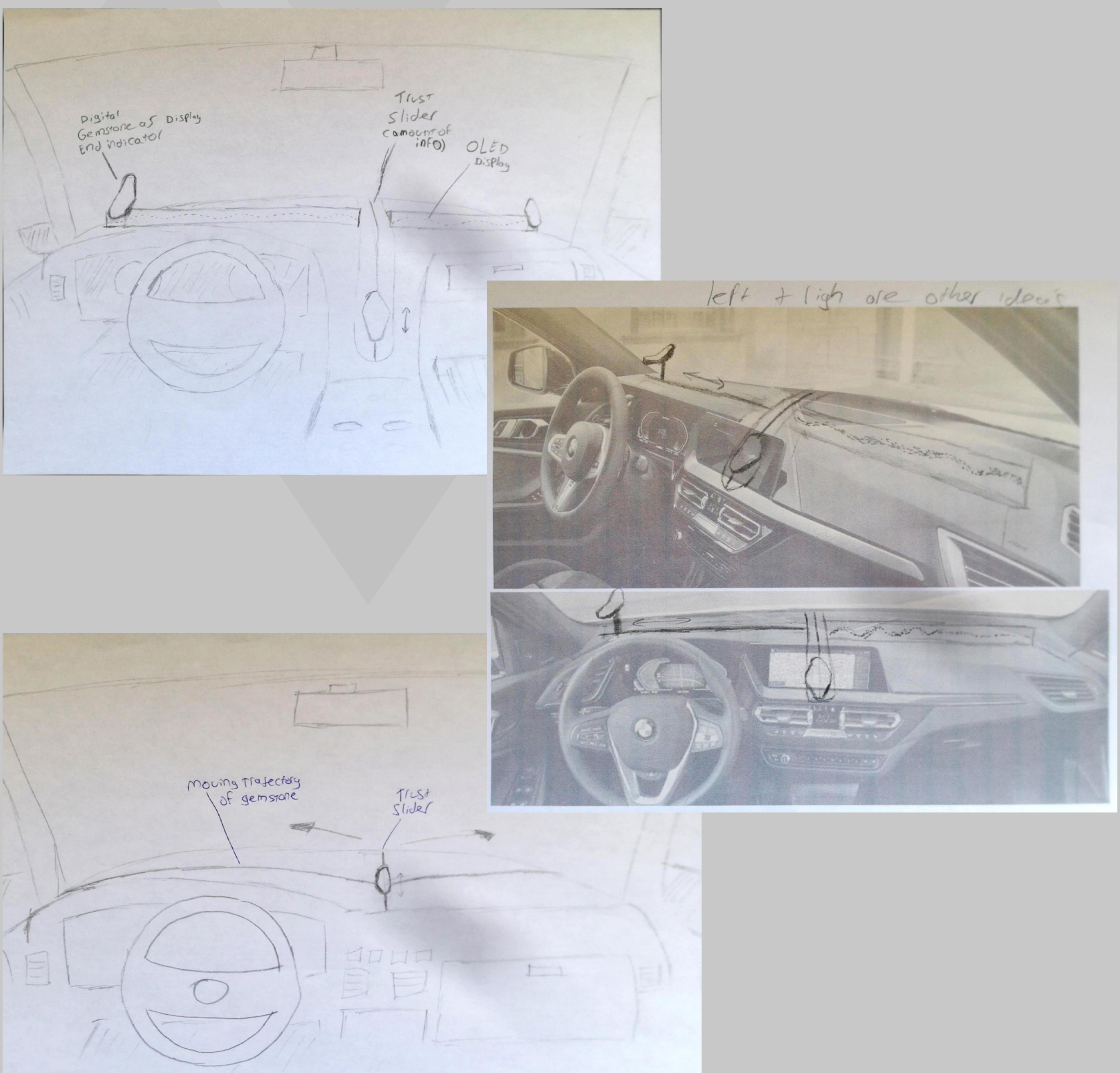

Figure 7: First design sketches

Combining the types of information from the result of the affinity diagram with the sketches that had the addition to the dashboard, a first design concept was made (figure 8 & 9).

Figure 8: First design concept (front view) (Tesla's Model 3 Interior, n.d.)

Figure 9: First design concept (side view) (Tesla's Model 3 Interior, n.d.)

This design concept includes a large display on the dashboard of an automated car. The display provides the user a continuous flow of information using swarm lights. It also includes the central slider from the sketches so the driver can adjust the amount of information. The amount of information that the display would show was divided into three settings:

Setting 1 (lowest trust / most information):
Warnings & Uncertainty/TOR + Future Actions + Situational Awareness
Setting 2 (moderate trust / moderate information) :
Warnings & Uncertainty/TOR + Future Actions
Setting 3 (high trust / least information):
Warnings & Uncertainty/TOR

Moving the central slider during the drive would lead to the display showing more or less context dependent information which can support the trust between car and user in different situations. As been said, the central slider also acts as a communication tool. This would be done by using haptic force feedback. When a user wants more information in an easy to handle situation, the slider requires more force to get more information such that the car will tell: "trust me, I can handle this situation".

A demonstrator was made to be able to communicate the design, including how the information would be displayed (figure 10). With use of styrofoam, a low-fidelity mini dashboard with a removable display was created. With use of wooden sticks and paper the movement and shape of the swarm particles could be shown as how they would look like and move on the display (figure 10). This demonstrator was used to communicate the concept in a video for the mid-term demo day.

Figure 10: Midterm Demo Day Demonstrator. Link to video : https://youtu.be/IlmPzDoMF7I

During and after the midterm demo day valuable feedback had been received. This feedback included several aspects. The two major things being feedback on the design and how to deal with the struggle I had to deal with.

The design included a large display with moving swarm lights. The use of light only was seen as a minimal way to show information. Moreover, moving the slider to set the amount of information felt as "accepting cookies" that one would do a single time and never again (personal communication, April 7, 2021).

The concept required visualizations of the moving of the lights in different situations, such that it would communicate how the lights would behave in these situations. The struggle was that making these visualizations would be hard for me since I do not have this expertise. Experimenting with the design was proposed such that the design could be improved and I could make use of the expertise I do have (personal communication, March 31, 2021). One way to do this was to make use of an analogue way to show information. Creating a prototype including these elements would show my expertise in Technology and Realization.

Design iteration

After the provided feedback, a brainstorm session was held, and new design iterations were made (figure 11). One promising concept included analogue elements on the dashboard that would move in various ways to show information.

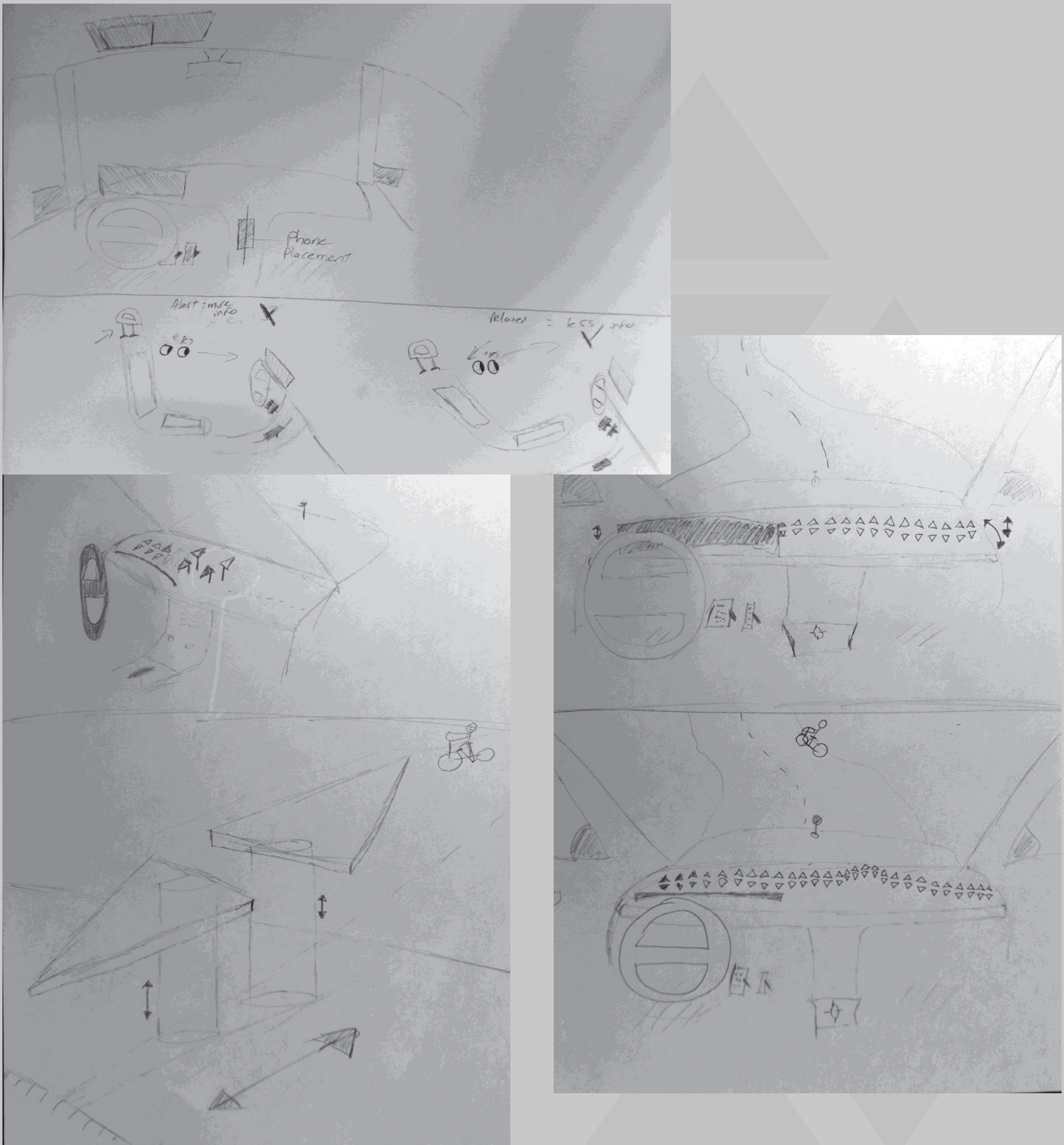

Figure 11: Design iteration skecthes

The fact that analogue elements were chosen was based on several aspects mentioned before. Moreover, personally I think that in fully autonomous cars there will be no screens anymore. Once it fully operates by itself, we can do other tasks (on our own screens, such as our smartphones) without being cautious. To still receive valuable information, analogue elements can be a great alternative to show this information.

The shape of the elements, two triangles pointing the opposite direction, was chosen since this shape has been used by BMW in several cars. Therefore, this design would suit BMW, the company I kept in mind during the design process. The idea included that the elements would be combined with the central slider and the settings made earlier. A prototype for this design concept could be realized with the expertise I have.

Up until this point in the project, the final design was kept too much in mind which caused the process to be a bit stuck. To stimulate the process, and to argument the design choices in the final design, smaller aspects of the design were investigated. This was done in two different ways: a survey and brainstorm sessions.

Survey

In the survey that was conducted, the central slider (figure 12 & 13) and the importance of the three types of information was studied. Participants had to indicate whether moving up or moving down the central slider would show more information. Next to that, they had to indicate the importance of each of the three types of information on a scale from 1 to 10. Moreover, demographics were asked as well as their trust in automated cars based on their current feeling and knowledge about these types of cars. An overview of the questions in the survey can be viewed in appendix B.

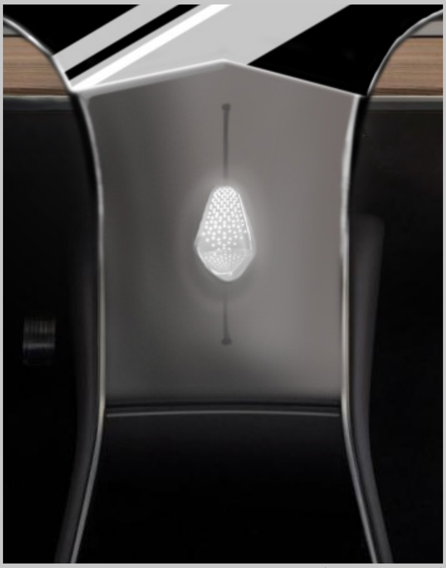

Figure 12: The central slider (front view)

Figure 13: The central slider (side view)

Results - In total 55 participants filled in the survey. 39 out of 55 participants answered that moving up the central slider would show more information (figure 14). On average, there is a minimal difference in the importance of each of the three types of information (figure 15). In a later stadium, it was therefore chosen to get rid of the settings and to make the showing of information even more personalized. This will be elaborated on in the *final design* section.

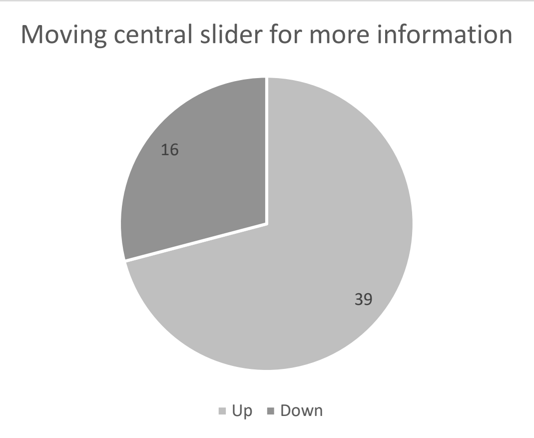

Figure 14: Survey result: moving central slider

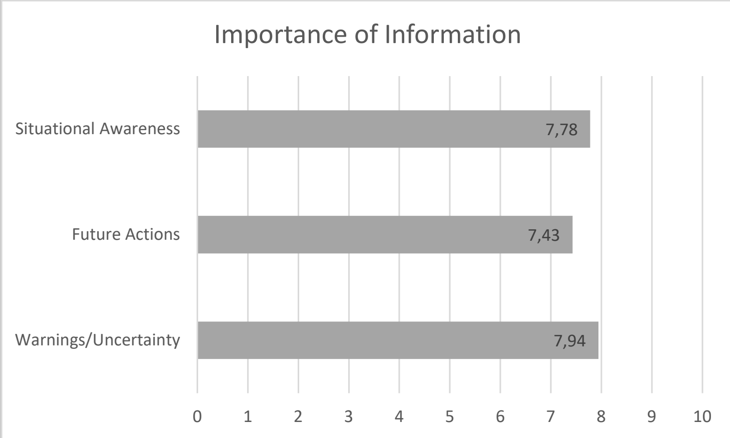

Figure 15: Survey result: Importance of information

The average trust in automated cars from the 55 participants is 5.78. The frequency of each score can be seen in figure 18. Remarkably, there is quite a large difference in trust in automated cars by gender (figure 16). Also students indicate they trust an automated car more than people with other employment statuses (figure 17). However, a 6.4 is still very low on a trust scale from 1-10. The scores in trust in automated cars was studied by calculating the mean, mode, median and standard deviation for all demographics. However, no interesting results apart from the ones given were found.

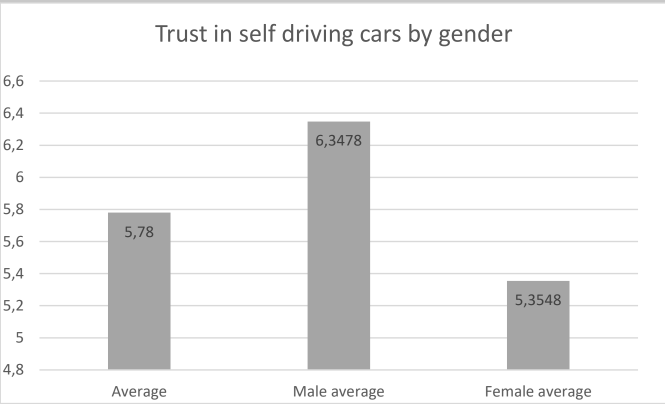

Figure 16: Survey result: Trust in self driving cars by gender

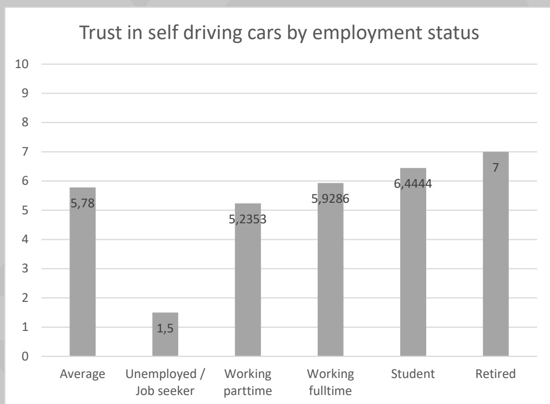

Figure 17: Survey result: Trust in self driving cars by employment status

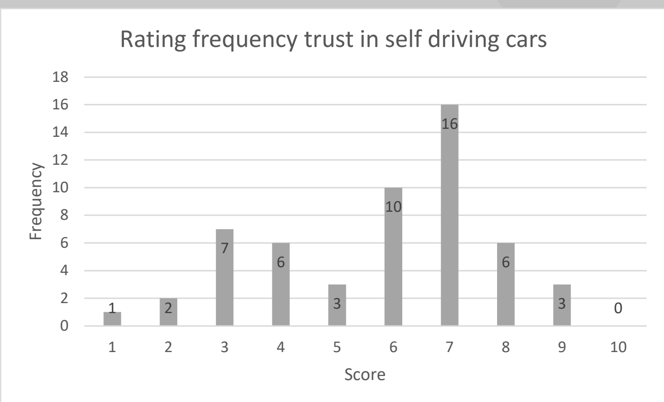

Figure 18: Survey result: Rating frequency trust in self driving cars

Brainstorm sessions

Brainstorm sessions were held to investigate how future users would perceive different aspects of the elements. At first, the participants were introduced to the project, after which they were introduced to the concept including the elements. The participants were then asked to brainstorm about what kind of information each of seven aspects could show. These aspects were:

- (change in) Height

Figure 19: Aspect Height (low)

Figure 20: Aspect Height (high)

- (change in) Place

Figure 21: Aspect Place (back)

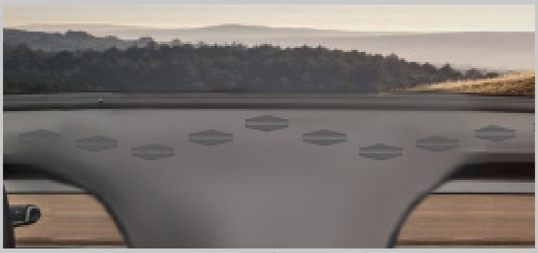

Figure 22: Aspect Place (forward)

- Turning

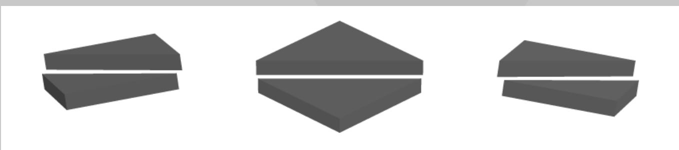

Figure 23: Aspect Turning (left & right)

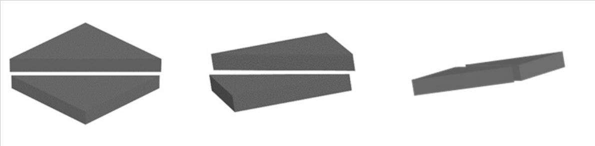

Figure 24: Aspect Turning (further right)

- Angle/Tilt

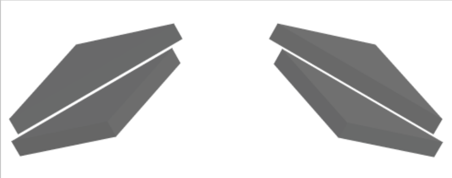

Figure 25: Aspect Tilt (left & right)

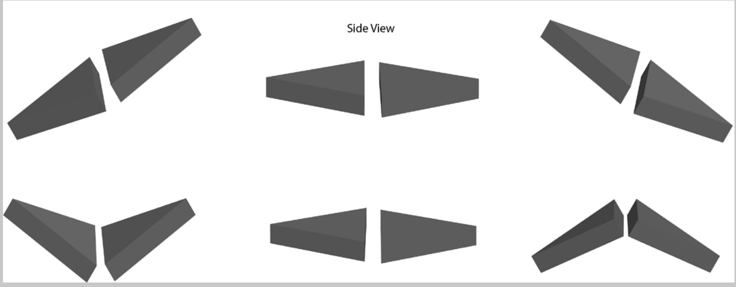

Figure 26: Aspect Angle

- Color

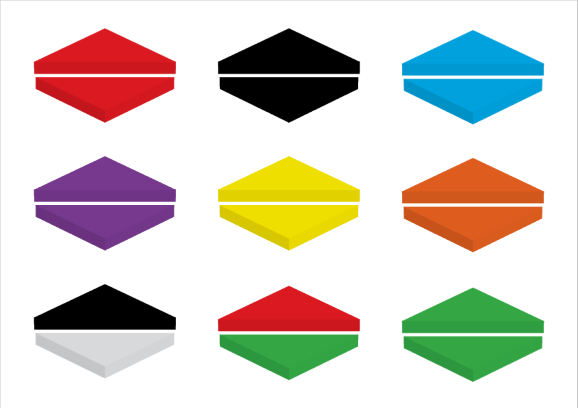

Figure 27: Aspect Color

- Number of elements

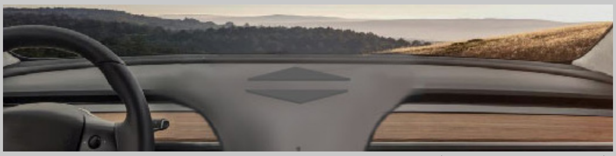

Figure 28: Aspect Number of elements (single element)

Figure 29: Aspect Number of elements (many elements)

- Shape

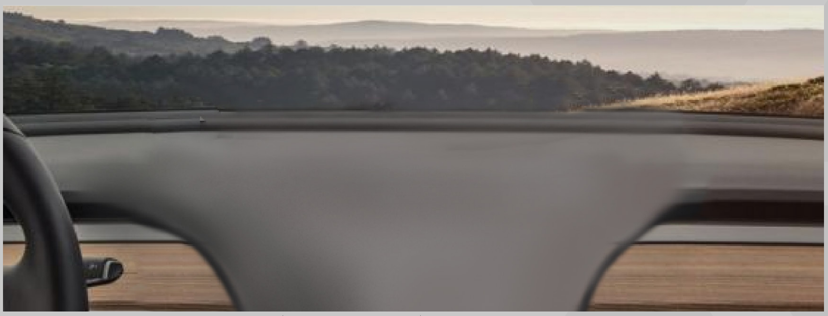

Figure 30: Aspect Shape (free to draw)

More example pictures of the aspects can be found in Appendix D.

After brainstorming about an aspect for five minutes, they had to link the information that they would perceive as most intuitive with this aspects of the elements. It was asked in the following way:

"Imagine you would step inside an automated vehicle that would include this concept. While being driven around, you see the elements do something (e.g. change in height, change in color). What information would the elements try to give you?"

The sessions were held with either 1 or 2 participants. The participants could brainstorm about the information that each aspect can show for 5 minutes. Each aspect included example pictures that were shown to the participants (Appendix D). After 5 minutes they were asked to answer the question what information would be most intuitive for each aspect. That an aspect would show no information and must not be included in the design for any reason was also a possible answer they could give. The session ended with a discussion about my own perception of what information each aspect would show in comparison with their perception.

Results - During the sessions, post-its were used to write down participant's ideas. Next to that, important notes were written down as well as the participants their answer to the question for each aspect.

In total 10 participants participated in the brainstorm sessions (Table 1). Using a qualitative content analysis, per aspect a table was made that shows the frequency (above 2) of the mentioned types of information that this aspect could show across all brainstorm sessions (Table 2). Moreover, a table was made that shows the answer to the asked question for each aspect, for each session. This table can be found in Appendix E.

Participant / demographics	Age	Employment status
Session 1		
P1	21	Student
Session 2		
P2	21	Student
P3	20	Student
Session 3		
P4	22	Student
P5	21	Full-time employment / student
Session 4		
P6	22	Full-time employment
P7	22	Student
Session 5		
P 8	18	Sabbatical
Session 6		
P 9	51	Full-time employment
P 10	50	Full-time employment

Table 1: Participants Demographics

In some of the aspects, one type of information rose as being most intuitive a high number of times, while other aspects show more variation in what participants perceive as the most intuitive information with these specific aspects. Within the aspect *height*, *(distance to) other traffic* was mentioned 6 times and for the aspect color, the use of traffic light colors was also mentioned 6 times.

Aspect	Information	Number of times mentioned
1. Height	(Distance to) other traffic	6
	Accelerate / brake	2
2. Place	Route	3
	Accelerate / brake	3
3. Turn	Route	6
	Point other traffic	2
4. Angle/Tilt	Direction / Intention: Lane changing / overtaking / highway exit	3
	Banking / angle of the road	2
5. Color	Red = danger / brake Orange = uncertainty Green= okay / go	6
	Combination with height: color for specific object/traffic	2
6. Number of elements	More elements = more chaos/stress	4
	TOR	2
	1 row of elements is good	3
	Customizable	3
7. Shape	Triangle / arrow = direction	5
	Triangle / arrow = intuitive	3

Table 2: Frequency of mentioned information per aspect

More variation can for instance be seen in the aspects *place* and *number of elements*. In the aspect *place*, both *route* and *accelerate/brake* were mentioned 3 times. In the aspect *number of elements* even four different answers were mentioned 2 or more times. Participants mentioned 4 times that more elements would be chaotic and increase stress. That this would indicate a Take Over Request was mentioned 2 times. It was 3 times mentioned that 1 row of elements across the entire dashboard would be great, while it was also mentioned 3 times that the number of elements in use must be customizable.

The aspect of shape requires some extra attention. The shape was inspired by the use of the same shape by BMW. Participants were asked what they think of this shape, and whether a different shape would be more intuitive. They were prompted to come up with ideas by making use of the sentence:

"if the shape would be a circle/square/differently, the information that would be intuitive for aspect X would be ...".

Even though one participant came up with the idea that different shapes could indicate different types of information, other participants found the current shape very intuitive (3x). It was mentioned 5 times that the chosen shape is very good for showing direction. Therefore, the final design makes use of the shape of 2 triangles pointing the opposite direction.

Both the survey and the brainstorm sessions have had their influence on design decisions towards the final design. This final design will be described in the next section.

Final Design

The process described in the previous section led to the design of the ITE system (figure 31). ITE (information through elements) intuitively provides the user with a continuous flow of personalized information through elements that are integrated in the dashboard of the car. In the following subsections ITE will be described in more detail.

Figure 31: The ITE System (Tesla's Model 3 Interior, n.d.)

Continous & Personal

The elements of the ITE system continuously give personal information to the user sitting inside the automated car. When the user enters the car, the elements dynamically move to let the user know they must select which elements they want to be active. When the car starts driving towards the destination, these selected elements move and change according to the information the user wants to receive. This makes that the information is given continuously.

During a drive, situations can occur in which future users might want to receive more or, conversely, less information in order to support their trust. Therefore, the amount of information, as well as the number of active elements, can be changed throughout the drive. This can be done through the settings of the car, or via the mobile application that comes with the car (figure 32 & 33). This makes the system personal.

The design is both continuous and personal, because literature shows that these factors can support trust

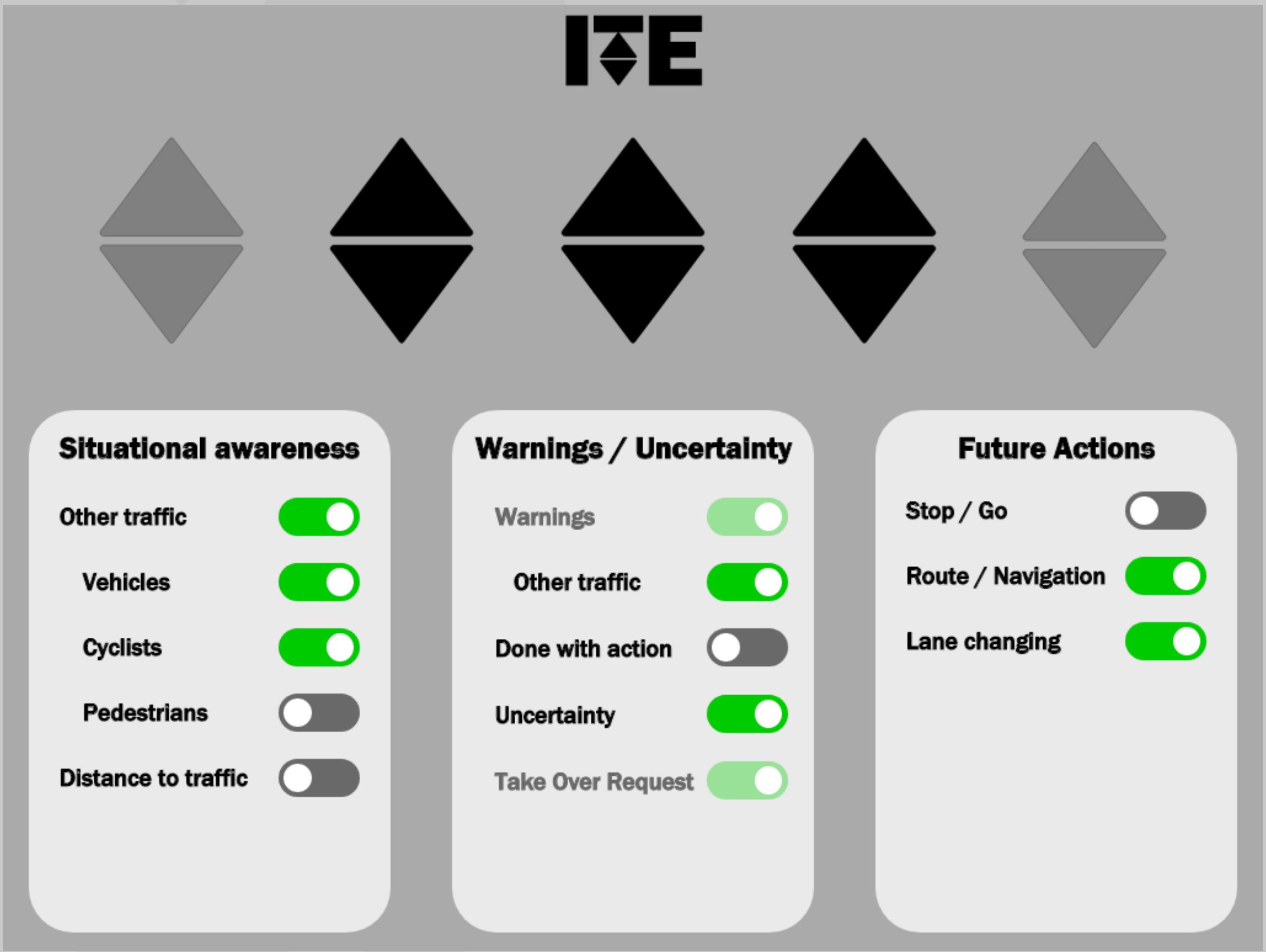

Figure 32: The ITE System settings in the car

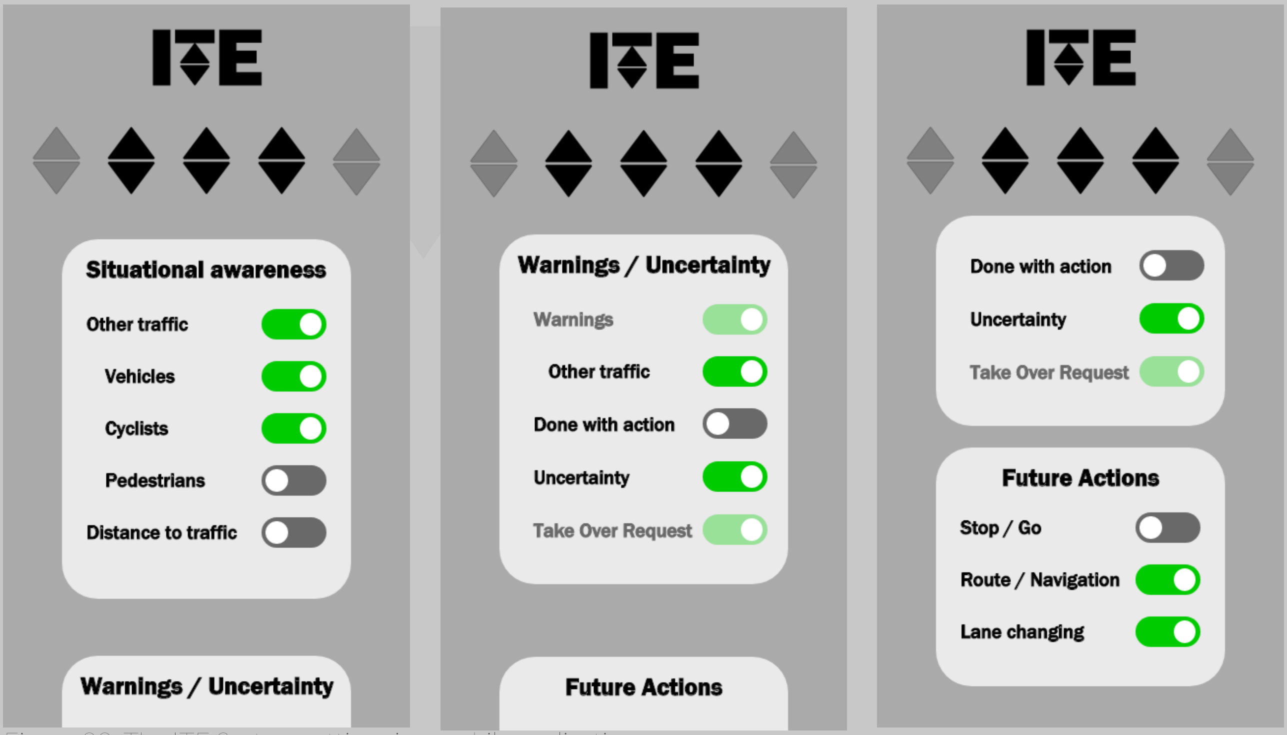

Figure 33: The ITE System settings in a mobile application

Information

The information that ITE shows can be categorized into 3 types of information. These are *Warnings & Uncertainty/TOR*, *Situational Awareness* and *Future actions*.

Warnings & uncertainty /TOR

In this category of information, the system will warn the user if there is urgent danger. Moreover, the system will show how (un)certain the car is of its performance, up until the point the car is not able to perform by itself anymore. This is called a Take Over Request (TOR). If the system shows a TOR, the user will be asked to take over the control of the car.

Situational Awareness

In this category of information, the system shows what it 'sees' on the outside of the car. This mainly involves other road users and the distance towards those other road users. It will show this to give the user inside an idea of what the car sees and recognize.

Future Actions

In this category of information, the system will show what the future actions of the car will be. This involves the direction/navigation of the car as well as changing lanes. By showing this information the user will not be surprised by what the car does.

These three categories of information were chosen after an analysis of literature. All three categories include more sorts of information that users will be able to turn on or off. For example, in the category Future Actions, the route can be turned on or off.

The survey showed that each of the categories of information are rated as being almost equally important. Therefore, the ITE system is not making use of settings within the information but is fully adjustable to personal needs within all three categories of information. However, both warnings and TOR will not be able to be turned off. This information is too important for the user to know.

Elements

The elements are the system's way of providing information to the user. The information is linked to several aspects of the elements.

(change in) Height

The elements can change in height (figure 19 & 20). If an element changes in height it means that the car has seen other road users (*Situational Awareness*). The height difference indicates the distance towards these other road users. The higher the element, the closer the distance towards this other road user. Moreover, an element will also point towards this other traffic.

The distance towards other road users linked to the change in height has been chosen because of the result of this aspect in the brainstorm sessions. It was mentioned six times during the 5-minute brainstorm session of this aspect (Table 2) and in all 6 sessions this information was chosen as being most intuitive with the aspect of height (Appendix E).

Turning
The turning of the elements (figure 23 & 24) indicates the route the car is driving (*Future Actions*). The more the elements are turned to a side (i.e. left), the closer the turn to this side is. During the time the car takes the turn, the element will turn back towards pointing straightforward, after which the element starts turning towards the next turn the car will take. Moreover, if there are other road users, turning will be used in combination with height to point towards the other road users (*Situational Awareness*).

That turning indicates the route has been chosen because of the result of this aspect in the brainstorm sessions. It was mentioned six times during the 5-minute brainstorm session of this aspect (Table 2) and in all 6 sessions this information was chosen as being most intuitive with the aspect of turning (Appendix E). Since it was mentioned 2 times that turning could also point towards other traffic in combination with height, this has been included for this aspect.

Tilt
The elements can tilt towards the left or right (figure 25). This indicates that the car is changing lanes towards the side the element is tilting (*Future Actions*). During the time the car will change lanes, the element will shift back to the horizontal position accordingly.

The decision to link changing lanes to the aspect of tilt has two main reasons. Firstly, it was mentioned and set as most intuitive for this aspect 3 times during the brainstorm of this aspect (Table 2 & Appendix E). Secondly, even though changing lanes can be seen as route, it is better perceived by using tilt. The reason for this is that changing lanes would be just a small turn of the element towards a side if it was included in route.

Color
The color of the elements (figure27) shows multiple sorts of information. Firstly, different tones of orange show uncertainty (Warnings & Uncertainty/TOR). More towards red is more uncertain. When the elements flash red, it shows a Take Over Request. When the elements turn green after the car has been uncertain for a while, or after the car has performed a specific action, it means that the situation is now fully under control again or the car is done performing this action.

The use of these colors in combination with the information has been chosen because of the results of the brainstorm session of this aspect. It was mentioned 6 times that the design could use traffic light colors (Red, Orange, Green) in combination with specific information (Table 2). Red for danger or TOR (6x), Orange for uncertainty (4x) and green for “okay/good” (6x).

Number of elements
The total number of elements that users can set active is five. Since ITE is personal, the user is also able to make use of a single element, as well as two, three or four. All five elements can be individually set active. This can be done by changing the settings as mentioned in the subsection *Continuous & Personal*.

The choice of five elements come from the results of the brainstorm session of this aspect. It was mentioned 3 times that a row of elements across the entire dashboard would be good (Table 2). However, it was also mentioned by a participant that this entire row already consists of too many elements. Next to that, another participant mentioned that a single element would be beneficial as well. Using a maximum of five elements is a great medium that can show information in a scattered way. The fact that the number of active elements can also be determined by the user is because it was mentioned 3 times that this should be customizable (Table 2).

Prototpye & Logo

To communicate the working of the ITE system, a prototype was made (figure 34). The elements were carved out of wood and the exact same shape was carved out of another piece of wood such that the elements would fit inside. Wooden sticks were placed inside the bottom of the elements such that the height, rotation and tilt of the elements could be manually controlled (figure 35). The center element has an extra layer of sanded plexiglass to diffuse light coming from RGB LEDs underneath this layer. To control these RGB LEDs, an ESP8266 was used in combination with the Blynk application (Blynk, 2017) (figure 36). Via buttons and a slider inside the mobile application, commands were sent to the ESP8266 to set the RGB LEDs to the right color (figure 37 & 38). The code can be found in appendix G. The prototype was used to showcase the working of ITE in the final video and through a series of photos (Appendix A).

Figure 34: The ITE System prototype. Link to video: https://youtu.be/SQliQNh6s78

Figure 35: The elements on a stick

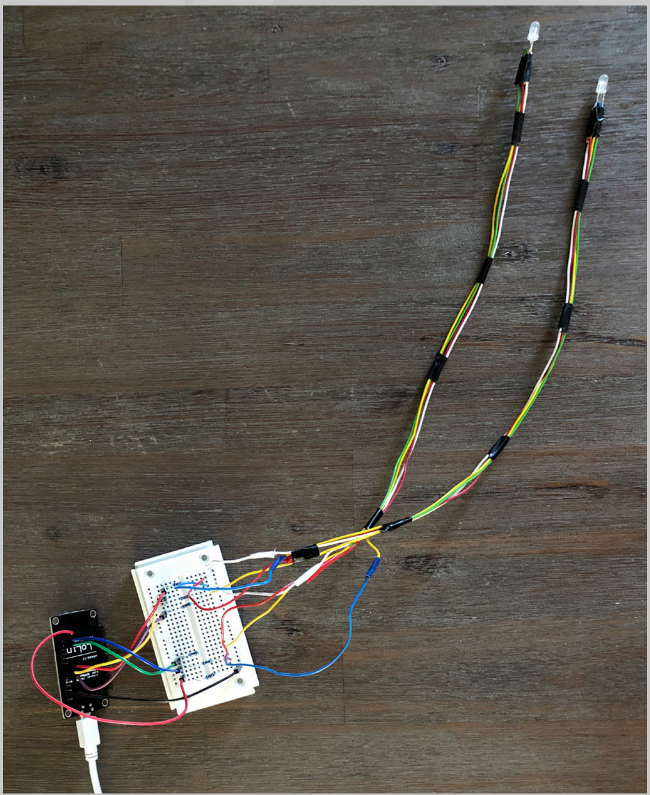

Figure 36: ESP8266 with 2 RGB LEDs

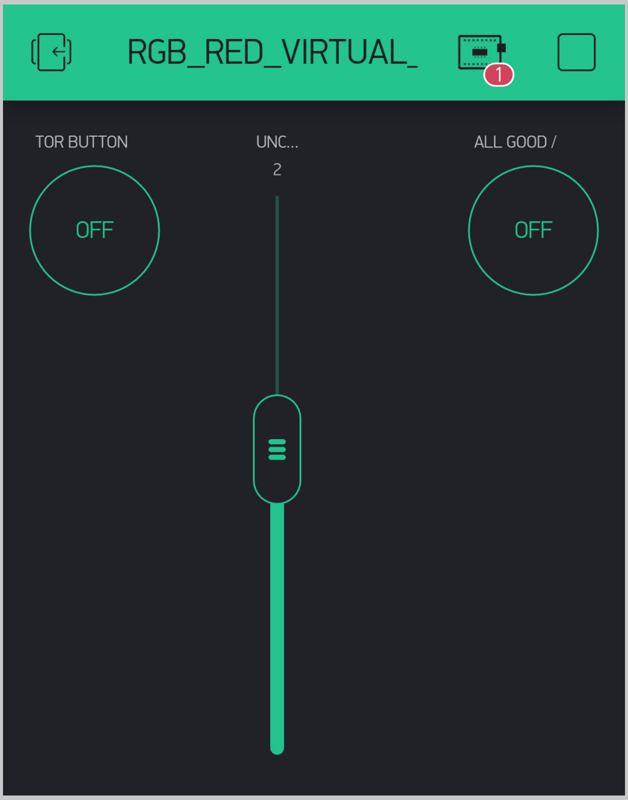

Figure 37: Project in Blynk Application

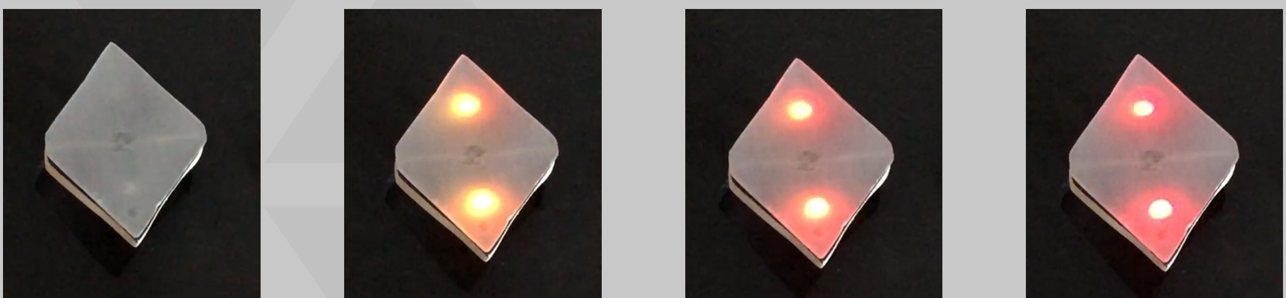

Figure 38: RGB LEDs showing *Uncertainty*

To show how the ITE system would appear inside an automated car, a picture of a Tesla model 3 has been photoshopped (Tesla's Model 3 Interior, n.d.)(figure 1 & 31). The same picture has been used for the example pictures in the brainstorm sessions.

To make the design a whole, a logo was created that suits the design, which then could be included in visuals. The logo has been chosen from a selection of logos created in an exploration towards an appropriate logo. This exploration can be viewed in Appendix F.

Discussion

After having completed this final bachelor project, some points of discussion emerged. Moreover, future work can be done to user test and validate the system. This section elaborates on the discussion points and includes recommendations for future work.

The ITE System

The ITE system provides information via the elements integrated in the dashboard. Providing this information is purely based on visual cues. Whether these visual cues would be enough to provide information to the user such that it supports trust is a main discussion point of the system. In the future, the system could for instance make us of a combination of the visual cues, and other cues such as sound and vibration. The combination of these cues can be studied in future work with the ITE system.

Throughout the report it has been mentioned that ITE, as well as previous designs, would show the right amount of information. However, the system does not know whether it actually shows the right amount of information in order to support trust. The input of how much information is shown is given by the user. In certain situations, the user might choose to receive too much or too little information to support trust, which can lead to distrust. Therefore, the focus of the ITE system must be on personalized information instead of the right amount of information.

Prototype

In a final design of ITE, all elements would be able to change color. However, due to time constraints and redundant work, the prototype only consists of a single element showing change of color via the colored LEDs to provide specific information. Due to this element looking differently between the other four elements, misperceptions of the ITE system may occur. One misperception that occurred during the Demo Day was that this different appearing central element would “be” the car, and the other elements would indicate other road users. When more time would have been available, all other elements would have had the extra layer of sanded plexiglass and the RGB LEDs such that these misperceptions would not have occurred. For future work, a prototype can be made that includes the change of color of all elements. Moreover, the elements can be motorized such that they will not have to be controlled manually during for instance user testing.

Brainstorm sessions & Survey

Brainstorm sessions about seven aspects of the elements were held to know what users perceive as intuitive what information each aspect shows. In total, 10 participants participated in the brainstorm sessions of which 8 were of age 22 or below. This can be seen as a limitation of these sessions. Participants of different age groups could have given other answers. A recommendation would be that in the future the brainstorm sessions could be done with more participants. This to study if more participants, and participants from different age groups, would give the same answers as the answers that were given by the ten participants. This would also create a stronger argument for the specific information that each aspect shows.

In total 55 respondents filled in the survey. Not all age groups were equally represented. To perform scientific tests with a similar survey in the future, more participants should fill in the survey such that all age groups are approximately equally represented.

User testing / validation

After finalizing the concept and prototype, no user tests were done due to time constraints. In future work user testing could be done to study whether the use of the ITE system actually supports trust in an automated car. A recommendation is to do this via a simulation study in which participants virtually sit in an automated car. In front of the simulation screen the dashboard including the ITE system would be shown. Participants can control the amount of information shown by a future prototype of the system via an application on their mobile phone. The participant would give the input to which elements are active and how much information the ITE system shows. The simulation would give the input to which information is shown based on certain simulation scenarios. After participating, the participants could be interviewed to investigate whether the system supports trust.

To validate the ITE system on a more business level, I recommend doing interviews with experts. In these interviews questions can be asked such as whether a company would actually incorporate this system in their future automated cars if it is proven to support trust.

Conclusion

To conclude, the ITE system is a design concept that partly satisfies the design goal of this final bachelor project. The system is used *inside an automated car* and gives *continuous and personalized* information to the user sitting inside. However, the discussion shows that user testing and future work must be performed too study whether the system actually *gains the user's trust* in an automated car *in times human drivers are transitioning from manual driving to using autonomous cars*. Moreover, it shows that there is much more to the concept than purely visual cues.

Acknowledgement

This extended report is made by a student from the faculty of Industrial Design at the University of Technology in Eindhoven in the context of the Final Bachelor Project. This report has been written in context of the design and development of the final design, the ITE system.

I want to thank:

• M. Martens for being my project coach during this process and providing me with the necessary feedback during the design process.

• The Future Mobility squad, including all other coaches and all students, for letting me perform this project within this squad. Also, for providing me with feedback during the (midterm) Demo-day and during the informal Microsoft Teams meetings.

• The participants, who either filled in the survey or participated in the brainstorm sessions, for providing me with the required user input to continue developing this project.

This project has been both a way to show my developed skills in different expertise areas, as well as to continue developing as a designer. I hope that these shown and new skills, as well as the effort put into the project, is reflected in this report, and has resulted in a well-developed and satisfying result.

Thank you.

June 10, 2021

Y.J. Thijssen

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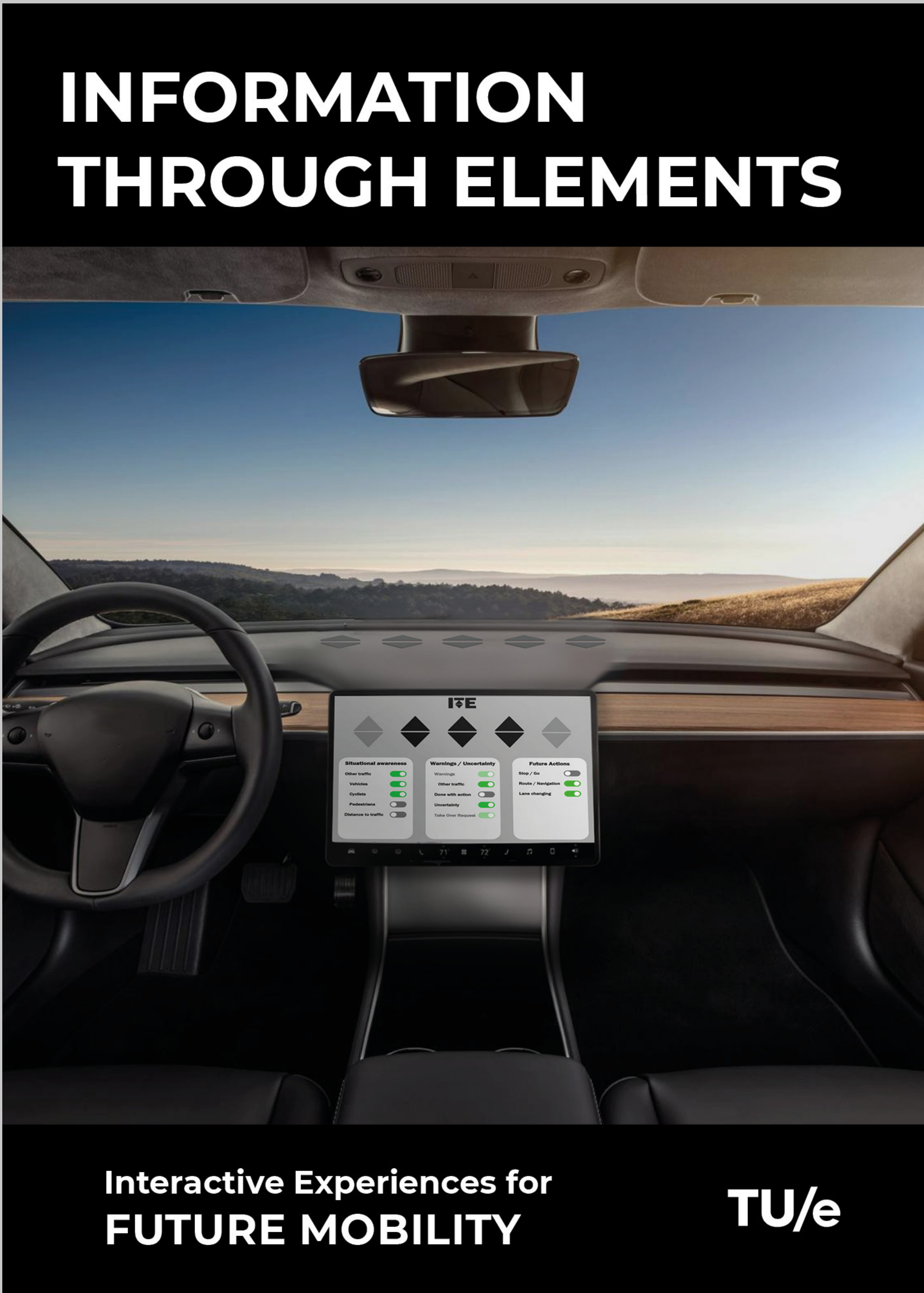
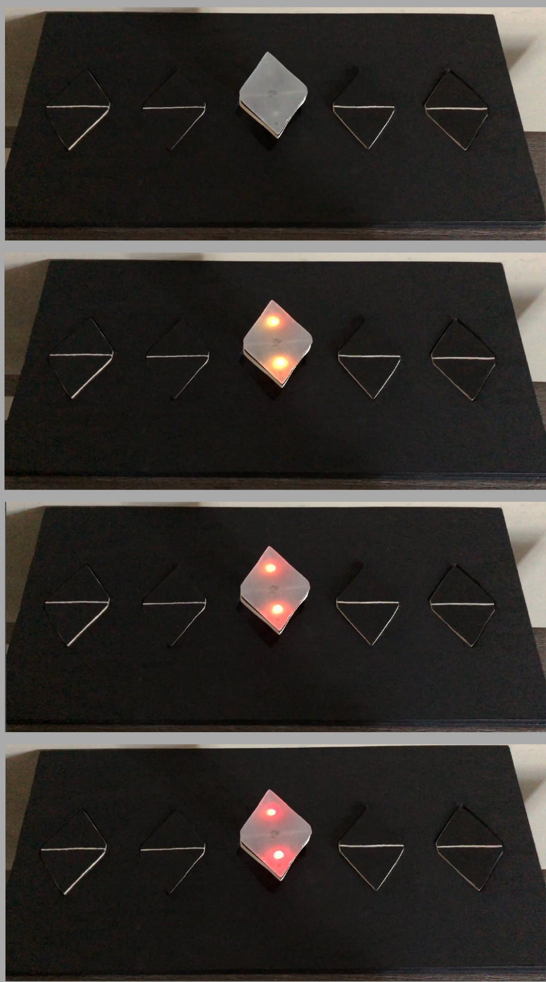
Appendices

Appendix A - Posters

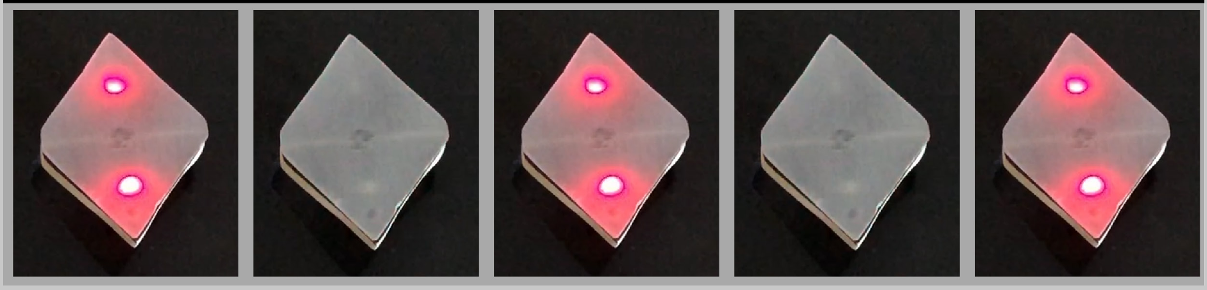
Appendix A1 - Demo Day Poster 1



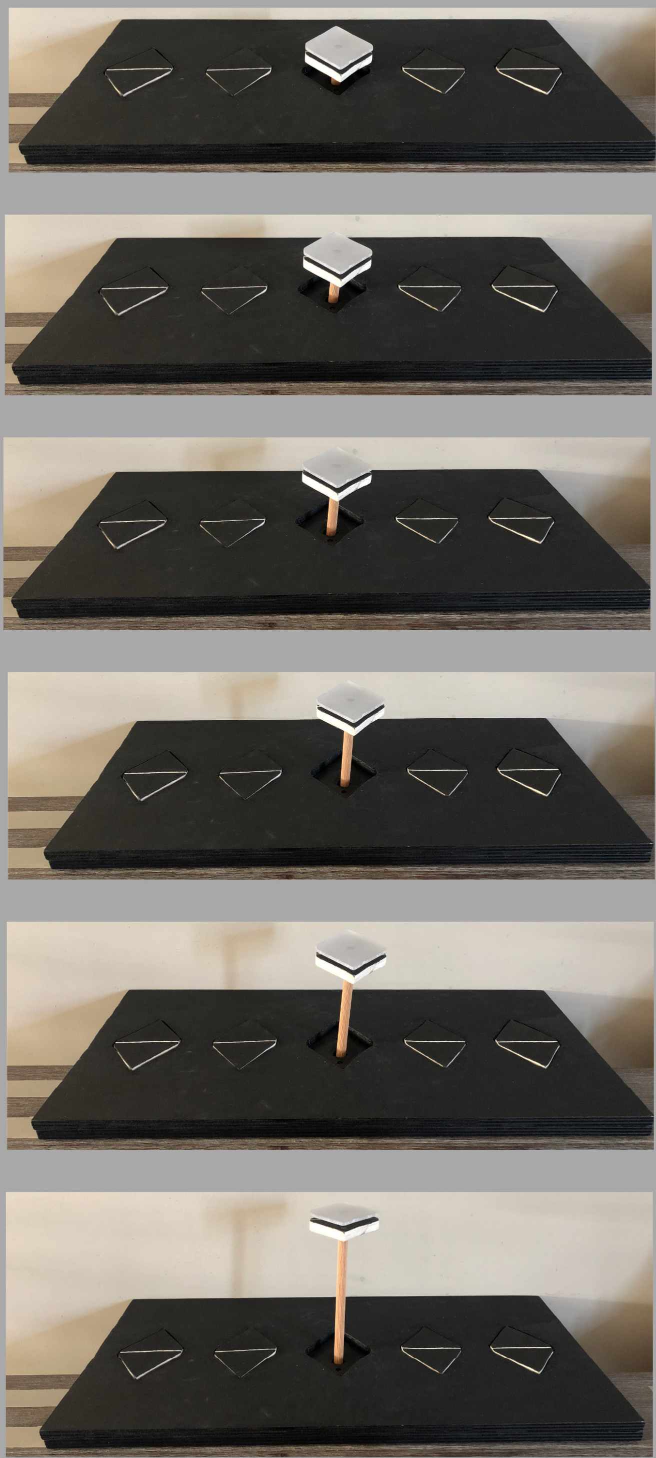
Warnings/Uncertainty:
Uncertainty



Warnings/Uncertainty:
Take Over Request



Situational Awareness:
(Distance to) other road users



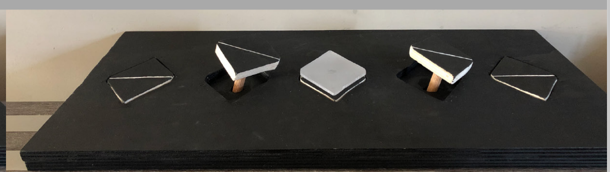
Appendix A4 - Demo Day Poster 4

Future actions:

Navigation

Future actions:

Lane Changing



Appendix B - Survey Questions

Survey Trust in Automated Cars

Welkom! Mijn naam is Yorn Thijssen en ik studeer Industrial Design aan de Technische Universiteit Eindhoven. Voor mijn eindproject doe ik een klein onderzoek naar vertrouwen in zelfrijdende auto's. Het zou heel fijn zijn als u mij kunt helpen door deze survey in te vullen. Het invullen zal ongeveer 5-10 minuten duren.

Velen zullen wel eens vaker van zelfrijdende auto's hebben gehoord. Auto's die ook zonder een bestuurder kunnen rijden, of waarin je als automobilist tijdelijk andere dingen kan doen omdat de auto het, bijvoorbeeld op de snelweg, zelf kan. Sommige zien het nog als verre toekomst, anderen zien het misschien binnenkort al gebeuren. Één ding is zeker: de transitie van rijden als mens, naar zelfrijdende auto's gebeurt niet binnen een nachtje, maar is een transitie die tijd kost.

Wat ook tijd kost is het krijgen van vertrouwen in de zelfrijdende prestaties van deze auto's tijdens deze transitie, omdat mensen er nog weinig ervaring mee hebben maar wel wellicht een mening hebben over hoe veilig of onveilig deze voertuigen zijn. Voor mijn eindproject ontwerp ik een toevoeging in het interieur van een zelfrijdende auto dat vertrouwen zal kunnen geven aan de gebruiker van deze zelfrijdende auto. Dit zal het doen door middel van het geven van informatie aan de gebruiker. Met het beantwoorden van deze vragenlijst helpt u mij om tot een goed eind ontwerp te komen.

Door op verder gaan te klikken gaat u akkoord dat u minimaal 16 jaar bent en anoniem deelneemt aan dit korte onderzoek. Uw gegevens zullen anoniem worden verwerkt en alleen gebruikt worden voor dit onderzoek. Er zal in de rapportage niets terug te vinden zijn dat herleid kan worden naar personen. U kunt op elk gewenst moment stoppen met het invullen van deze vragenlijst. De gegevens worden dan niet verzonden en dus ook niet meegenomen in het onderzoek. Mochten er vragen zijn of is er meer interesse in het project, schroom dan niet om contact op te nemen via: y.j.thijssen@student.tue.nl

Sectie 1 ...

Vragen Algemeen

In dit eerste gedeelte van de vragenlijst zullen een aantal algemene vragen gesteld worden.

1

Wat is uw geslacht? *

- Man
- Vrouw
- Anders
- Zeg ik liever niet

2

Wat is uw leeftijd? *

- 16-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-65
- 65+
- Zeg ik liever niet

3

Wat is het hoogste opleidingsniveau dat u hebt voltooid of de hoogste graad die u hebt behaald? *

- Lager dan middelbareschooldiploma
- Middelbareschooldiploma of vergelijkbaar
- MBO diploma
- HBO of universiteit maar (nog) geen diploma
- Bachelor degree
- Master degree
- Kandidaats/PhD

4

Wat is uw arbeidsstatus? *

- Werkloos / werkzoekende
- Werkzaam parttime
- Werkzaam fulltime
- Student
- Gepensioneerd

5

Heeft u een rijbewijs? *

- Ja
- Nee

Sectie 2

...

Vragen over vertrouwen in zelfrijdende auto's

In de volgende vragen zullen er vragen gesteld worden over uw vertrouwen in zelfrijdende auto's, en waarom u deze wel/niet vertrouwt.

In de volgende vragen wordt een zelfrijdende auto beschouwd als een auto waarin de bestuurder tijdelijk andere dingen kan doen omdat de auto het, bijvoorbeeld op de snelweg, zelf kan. In sommige situaties kan de auto het niet meer zelf en zal het de persoon in de bestuurdersstoel vragen controle terug te nemen, waar deze persoon dan ook de tijd voor heeft. Anders zet de auto zichzelf zo snel mogelijk aan de kant waar mogelijk. In deze auto is dus een rijbewijs nog wel noodzaak.

6

Gebaseerd op uw huidige kennis en gevoel ten aanzien van zelfrijdende auto's: Zou u een zelfrijdende auto vertrouwen? Hiermee wordt bedoeld: zou u de zelfrijdende functies van deze zelfrijdende auto gebruiken in het dagelijk leven zoals u wellicht nu een auto gebruikt of zou gebruiken? Geef dit aan op een schaal van 1 tot 10, waarbij 1 = geen vertrouwen en 10 = volledig vertrouwen. *

1 2 3 4 5 6 7 8 9 10

7

Verklaar uw antwoord op de vorige vraag. Waarom hebt u geen/minder, of wel/meer vertrouwen in in (gedeeltelijk) zelfrijdende auto? *

Voer uw antwoord in

Vragen over Informatie

De volgende vragen gaan over de informatie die een zelfrijdende auto kan bieden aan de gebruiker, en de manier waarop de hoeveelheid informatie kan worden aangepast. Op basis van literatuur heb ik een onderscheid gemaakt tussen 3 verschillende soorten informatie.

Waarschuwingen / onzekerheid (overnameverzoek)
In deze categorie informatie zal de zelfrijdende auto de gebruiker waarschuwen als er dringend gevaar dreigt. Bovendien zal de auto aangeven hoe zeker het is van zijn prestaties, tot het punt dat de auto het zelf niet meer kan en een overname verzoek doet. Als de auto dit verzoekt zal de bestuurder de controle van de auto over moeten nemen, en hier voldoende tijd voor krijgen.

Toekomstige Acties
In deze categorie informatie geeft de auto aan wat de toekomstige acties zijn. Denk hierbij bijvoorbeeld aan navigatie (linksaf/rechtsaf), maar ook bijvoorbeeld dat de auto van rijstrook gaat veranderen of een snelweg verlaat. De auto kan het dus zelf maar wil de mens niet verrassen door wat het doet.

Omgevingsbewustzijn
In deze categorie informatie geeft de auto aan wat het buiten de auto 'ziet'. Hierbij kunt u denken aan verkeersborden, maar ook aan ander verkeer en de afstand tot dit verkeer. Dit om mensen in het voertuig meer idee te geven van wat het voertuig ziet en herkent.

Ook in de volgende vragen wordt een zelfrijdende auto beschouwd als een auto waarin de bestuurder tijdelijk andere dingen kan doen omdat de auto het, bijvoorbeeld op de snelweg, zelf kan. In sommige situaties kan de auto het niet meer zelf en zal het de persoon in de bestuurdersstoel vragen controle terug te nemen, waar deze persoon dan ook de tijd voor heeft. Anders zet de auto zichzelf zo snel mogelijk aan de kant waar mogelijk. In deze auto is dus een rijbewijs nog wel noodzaak.

8

In het idee voor mijn ontwerp kan de gebruiker (tijdens de rit) de hoeveelheid informatie aanpassen door middel van een centrale controller (figuur beneden).

Wat zou voor u een logische beweging van deze centrale controller zijn om meer informatie te verkrijgen van de auto? Een beweging omhoog of een beweging omlaag? *


- De centrale controller omhoog schuiven geeft meer informatie
- De centrale controller omlaag schuiven geeft meer informatie

9

Hoe belangrijk is voor u de informatie "Waarschuwingen / onzekerheid (overnameverzoek)", om vertrouwen te krijgen in een zelfrijdende auto? Geef dit aan op een schaal van 1 tot 10 waarbij 1 = niet belangrijk en 10 = zeer belangrijk *

9

Hoe belangrijk is voor u de informatie "Waarschuwingen / onzekerheid (overnameverzoek)", om vertrouwen te krijgen in een zelfrijdende auto? Geef dit aan op een schaal van 1 tot 10 waarbij 1 = niet belangrijk en 10 = zeer belangrijk. *

1 2 3 4 5 6 7 8 9 10

10

Hoe belangrijk is voor u de informatie "Toekomstige Acties", om vertrouwen te krijgen in een zelfrijdende auto? Geef dit aan op een schaal van 1 tot 10 waarbij 1 = niet belangrijk en 10 = zeer belangrijk. *

1 2 3 4 5 6 7 8 9 10

11

Hoe belangrijk is voor u de informatie "Omgevingsbewustzijn", om vertrouwen te krijgen in een zelfrijdende auto? Geef dit aan op een schaal van 1 tot 10 waarbij 1 = niet belangrijk en 10 = zeer belangrijk. *

1 2 3 4 5 6 7 8 9 10

+ Nieuwe toevoegen

Appendix C - Consent form Brainstorm Sessions

Informatie voor deelname aan wetenschappelijk onderzoek

Brainstorm & Discussie sessie vertrouwen in zelfrijdende auto's

Inleiding

Geachte heer/mevrouw,

Wij vragen u om mee te doen aan een wetenschappelijk onderzoek.
Meedoen is vrijwillig. Om mee te doen is wel uw schriftelijke toestemming nodig. Voordat u beslist of u wilt meedoen aan dit onderzoek, krijgt u uitleg over wat het onderzoek inhoudt. Lees deze informatie rustig door vraag de onderzoeker naar uitleg als u vragen heeft. U kunt er ook over praten met uw partner, vrienden of familie.

1. Algemene informatie & Doel

Deelnemers nemen deel aan een Brainstorm & discussie sessie over het weergeven van informatie in een (gedeeltelijk) zelfrijdende auto. Het doel van deze sessie is om informatie te bedenken en te koppelen aan diverse aspecten van een ontwerp dat zal worden gebruikt in een zelfrijdende auto, om de gebruiker meer vertrouwen te geven in deze auto.

2. Wat meedoen inhoudt

Tijdens het onderzoek zullen 2 deelnemers uitleg krijgen over het onderwerp en de sessie. Hierna gaan de deelnemers met elkaar brainstormen over informatie per aspect van een ontwerp. Per aspect brainstormen deelnemers voor een bepaald aantal minuten en koppelen zij informatie aan dit aspect, waarna er een ander aspect volgt. Na alle aspecten te hebben besproken gaan de deelnemers in dialoog met de onderzoeker. Het onderzoek zal naar keuze van beide deelnemers online of offline gehouden worden.
Er worden gegevens verzameld over

- Ideeën over informatie
- De koppeling met het aspect van het ontwerp
- Leeftijd
- Studie / beroep
- Een audio opname zal worden gemaakt. Belangrijke stukken uit deze audio opname zullen worden getranscribeerd op anonieme wijze en worden opgeslagen en beveiligd met een wachtwoord. Het originele audiobestand zal hierna worden verwijderd.

3. Als u niet wilt meedoen of wilt stoppen met het onderzoek

U beslist zelf of u meedoet aan het onderzoek. Deelname is vrijwillig.
Als u wel meedoet, kunt u zich altijd bedenken en toch stoppen, ook tijdens het onderzoek.
U hoeft niet te zeggen waarom u stopt. Wel moet u dit direct melden aan de onderzoeker.
De gegevens die tot dat moment zijn verzameld, worden gebruikt voor het onderzoek.

Uw deelname aan het onderzoek stopt als

- u zelf kiest om te stoppen
- het einde van het hele onderzoek is bereikt
- de onderzoeker het beter voor u vindt om te stoppen
- de overheid of de beoordelende adviescommissie, besluit om het onderzoek te stoppen.

Het hele onderzoek is afgelopen als alle deelnemers klaar zijn.

4. Gebruik en bewaren van uw gegevens

Voor dit onderzoek worden enkele persoonsgegevens gebruikt en bewaard. Het gaat om gegevens zoals uw naam, leeftijd en studie / beroep. Het verzamelen, gebruiken en bewaren van uw gegevens is nodig om de vragen die in dit onderzoek worden gesteld te kunnen beantwoorden en de resultaten te kunnen publiceren. Wij vragen voor het gebruik van uw gegevens uw toestemming.

Vertrouwelijkheid van uw gegevens

Om uw privacy te beschermen krijgen uw gegevens een code. Uw naam en andere gegevens die u direct kunnen identificeren worden daarbij weggelaten. Alleen met de sleutel van de code zijn gegevens tot u te herleiden. De sleutel van de code blijft veilig opgeborgen in de lokale onderzoeksinstelling. In rapporten en publicaties over het onderzoek zijn de gegevens niet tot u te herleiden.

Toegang tot uw gegevens voor controle

Sommige personen kunnen op de onderzoekslocatie toegang krijgen tot al uw gegevens. Ook tot de gegevens zonder code. Dit is nodig om te kunnen controleren of het onderzoek goed en betrouwbaar is uitgevoerd. Personen die ter controle inzage kunnen krijgen in uw gegevens zijn: de commissie die de veiligheid van het onderzoek in de gaten houdt. Zij houden uw gegevens geheim. Wij vragen u voor deze inzage toestemming te geven.

Bewaartermijn gegevens

Uw gegevens moeten 5 jaar worden bewaard op de onderzoekslocatie.

Bewaring en gebruik van gegevens voor ander onderzoek.
Uw gegevens kunnen na afloop van dit onderzoek ook nog van belang zijn voor ander wetenschappelijk onderzoek. Daarvoor zullen uw gegevens 5 jaar worden bewaard. U kunt op het toestemmingsformulier aangeven of u hier wel of niet mee instemt. Indien u hier niet mee instemt, kunt u gewoon deelnemen aan het huidige onderzoek.

Intrekken toestemming
U kunt uw toestemming voor gebruik van uw persoonsgegevens altijd weer intrekken. Dit geldt voor dit onderzoek en ook voor het bewaren en het gebruik voor het toekomstige onderzoek. De onderzoeksgegevens die zijn verzameld tot het moment dat u uw toestemming intrekt worden nog wel gebruikt in het onderzoek.

Meer informatie over uw rechten bij verwerking van gegevens
Voor algemene informatie over uw rechten bij verwerking van uw persoonsgegevens kunt u de website van de Autoriteit Persoonsgegevens raadplegen.

Bij vragen over uw rechten kunt u contact opnemen met de verantwoordelijke voor de verwerking van uw persoonsgegevens. Voor dit onderzoek is dat:

Yorn Thijssen voor de TU/e. Zie bijlage A voor contactgegevens

Bij vragen of klachten over de verwerking van uw persoonsgegevens raden we u aan eerst contact op te nemen met de onderzoekslocatie. U kunt ook contact opnemen met de Functionaris voor de Gegevensbescherming van de instelling (Bijlage A) of de Autoriteit Persoonsgegevens.

5. Heeft u vragen?

Bij vragen kunt u contact opnemen met Yorn Thijssen.
Indien u klachten heeft over het onderzoek, kunt u dit bespreken met de onderzoeker. Alle gegevens vindt u in **bijlage A**: Contactgegevens.

6. Ondertekening toestemmingsformulier

Wanneer u voldoende bedenktijd heeft gehad, wordt u gevraagd te beslissen over deelname aan dit onderzoek. Indien u toestemming geeft, zullen wij u vragen deze op de bijbehorende toestemmingsverklaring schriftelijk te bevestigen. Door uw schriftelijke toestemming geeft u aan dat u de informatie heeft begrepen en instemt met deelname aan het onderzoek.
Het handtekeningenblad wordt door de onderzoeker bewaard. Zowel uzelf als de onderzoeker ontvangen een getekende versie van deze toestemmingsverklaring.

Dank voor uw aandacht.

7. Bijlagen bij deze informatie

A. Contactgegevens
B. Toestemmingsformulier(en)

Bijlage A: contactgegevens voor TU/e

Onderzoeker:
Yorn Thijssen
y.j.thijssen@student.tue.nl
+316-11414826

Functionaris voor de Gegevensbescherming van de instelling:
A.H.J. (Annuska) van den Eijnden
dataprotectionofficer@tue.nl

Voor klachten of meer informatie over uw rechten: contacteer y.j.thijssen@student.tue.nl

Bijlage B: toestemmingsformulier deelnemer

Brainstorm & Discussie sessie vertrouwen in zelfrijdende auto's.

- Ik heb de informatiebrief gelezen. Ook kon ik vragen stellen. Mijn vragen zijn voldoende beantwoord. Ik had genoeg tijd om te beslissen of ik meedoe.
- Ik weet dat meedoen vrijwillig is. Ook weet ik dat ik op ieder moment kan beslissen om toch niet mee te doen of te stoppen met het onderzoek. Daarvoor hoef ik geen reden te geven.
- Ik geef toestemming voor het verzamelen en gebruiken van mijn gegevens voor de beantwoording van de onderzoeksvraag in dit onderzoek.
- Ik weet dat voor de controle van het onderzoek sommige mensen toegang tot al mijn gegevens kunnen krijgen. Die mensen staan vermeld in deze informatiebrief. Ik geef toestemming voor die inzage door deze personen.

- Ik geef □ **wel**
  □ **geen**
  toestemming om mijn persoonsgegevens langer te bewaren en te gebruiken voor toekomstig onderzoek.
- Ik geef □ **wel**
  □ **geen**
  toestemming om mij na dit onderzoek opnieuw te benaderen voor een vervolgonderzoek.
- Ik wil meedoen aan dit onderzoek.

Naam deelnemer:

Handtekening: Datum : __ / __ / __

Ik verklaar dat ik deze deelnemer volledig heb geïnformeerd over het genoemde onderzoek.

Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de deelnemer zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Naam onderzoeker (of diens vertegenwoordiger):

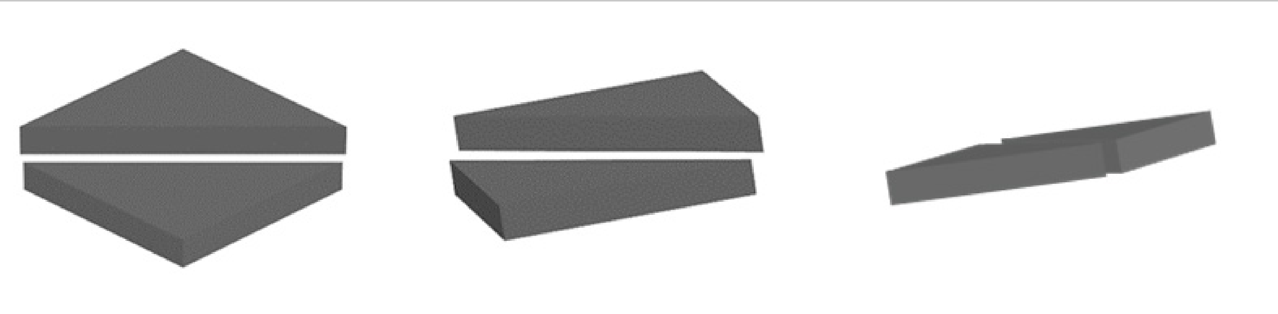
Handtekening: Datum: __ / __ / __

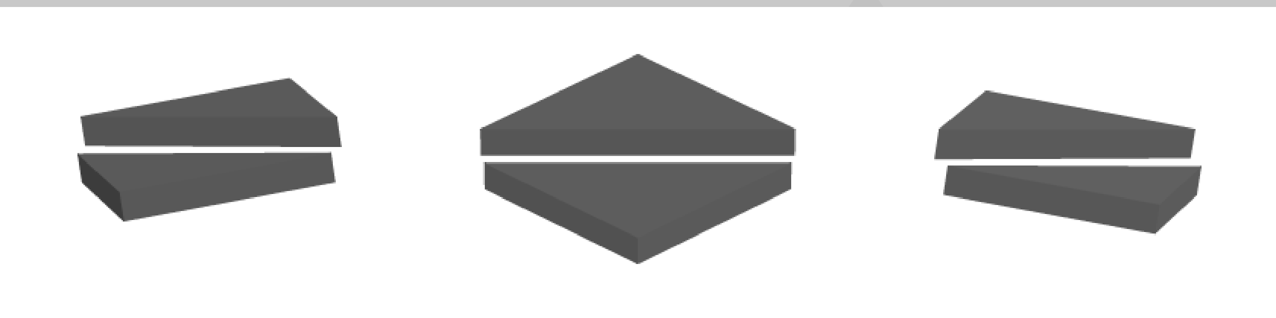
Appendix D - Example Pictures Brainstorm Sessions

Height

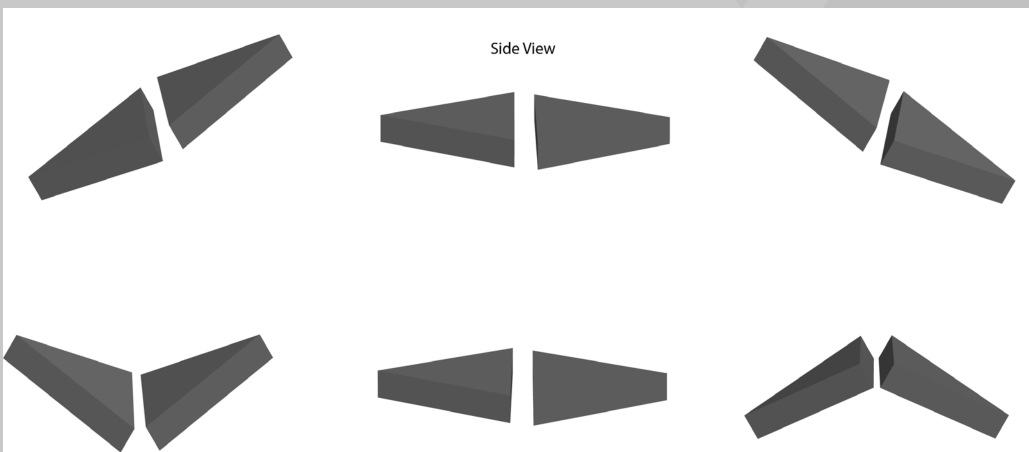
Place

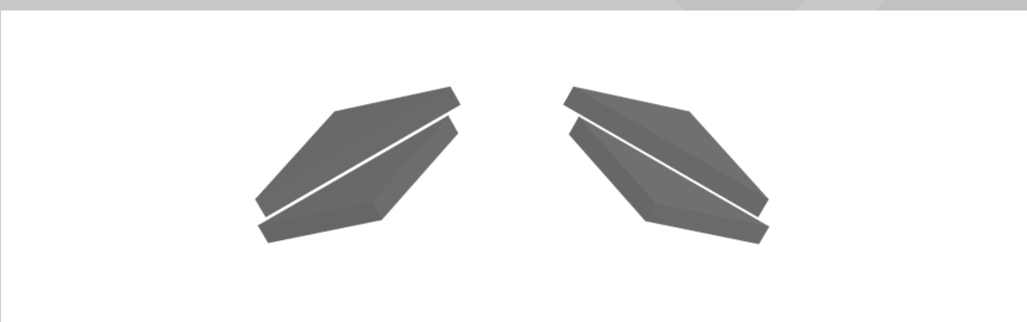
Turning



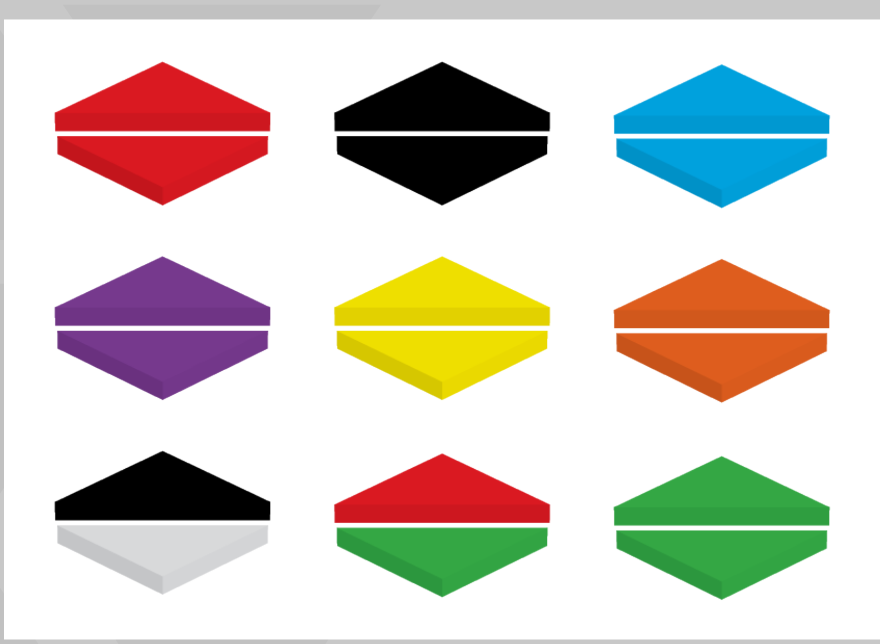


Angle / Tilt



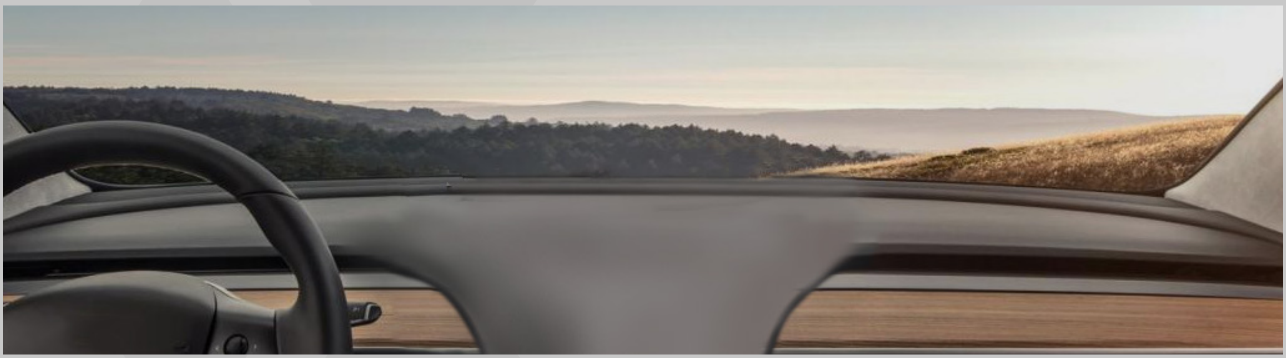


Color



Number of elements

Shape (free to draw)



Appendix E - Table: Most intuitive Information per aspect per session

Aspect	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
1 Height	Distance to other traffic	Distance to other traffic	(Distance to) other traffic	Distance to other traffic	Distance to other traffic	(Distance to) other traffic
2 Place	Information at specific place for specific person	-	-Intern car functions - route	Customizable	Distance to other traffic	-
3 Turn	Route / Compass Where to look if TOR	Route	Route	Route Other traffic	Route	Route
4 Angle	Tilt = intention of car	Banking / angle of the road	Error code Tilt = lane shifting / overtaking / highway exit	Tilt: direction Brake / accelerate	Tilt = lane shifting / overtaking / highway exit	Tilt = lane shifting / overtaking / highway exit
5 Color	Green = Good Orange = mediocre Red = Bad	Red = danger Orange = uncertainty Green = okay / done with action	Red = danger Orange = uncertainty Green = okay	Red = danger Orange = uncertainty Green = okay	Red = danger Orange = uncertainty Green = okay	Red = danger Orange = uncertainty Green = okay
6 Amount	1 Element	1 row of elements	1 row of elements Customizable	Specific amount in specific places Customizable	1 row of elements Customizable	1 row of elements = too many customizable
7 Shape	Triangle / arrow = direction	Triangle / arrow intuitively shows direction.	Triangle/arrow = intuitive / pleasant	Triangle / arrow = direction. Shape should suit car interior	Triangle / arrow intuitively shows direction.	Triangle / arrow shows direction.

Appendix F - Logo Exploration

1.

2.

3.

4.

Information Through Elements

5.

6.

7.

8.

Information Through Elements

9.

ITE

Information Through Elements

Appendix G - ESP8266 Code

```
/*************************************************************
  Download latest Blynk library here:
    https://github.com/blynkkk/blynk-library/releases/latest

  Blynk is a platform with iOS and Android apps to control
  Arduino, Raspberry Pi and the likes over the Internet.
  You can easily build graphic interfaces for all your
  projects by simply dragging and dropping widgets.

    Downloads, docs, tutorials: http://www.blynk.cc
    Sketch generator:           http://examples.blynk.cc
    Blynk community:            http://community.blynk.cc
    Follow us:                  http://www.fb.com/blynkapp
                                http://twitter.com/blynk_app

  Blynk library is licensed under MIT license
  This example code is in public domain.

 *************************************************************

  You can send/receive any data using WidgetTerminal object.

  App project setup:
    Terminal widget attached to Virtual Pin V1
 *************************************************************/

/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// You should get Auth Token in the Blynk App.
// Go to the Project Settings (nut icon).
char auth[] = "rju893frTWri-e1pVgQB_sAiS1nJuF_r";

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "WW_2.4G";
char pass[] = "14f95G973";

int red_pin1 = D0;
int blue_pin1 = D1;
int green_pin1 = D2;

int red_pin2 = D5;
int blue_pin2 = D6;
int green_pin2 = D7;

int on_time = 500;
int off_time = 500;

// void RGB_color(int redPin, int bluePin, int greenPin, int
red_light_value, int green_light_value, int blue_light_value);


BLYNK_WRITE(V1) //TOR
{
  int pinValue = param.asInt(); // assigning incoming value from pin V1 to
a variable
```

```
  // You can also use:
  // String i = param.asStr();
  // double d = param.asDouble();
  Serial.print("V1 value is: ");
  Serial.println(pinValue);

  if (pinValue == 1) {
    for (int i = 0; i < 5; i++) {
      RGB_color(red_pin1, blue_pin1, green_pin1, 255, 0, 0);
      RGB_color(red_pin2, blue_pin2, green_pin2, 255, 0, 0);
      delay(on_time);
      RGB_color(red_pin1, blue_pin1, green_pin1, 0, 0, 0);
      RGB_color(red_pin2, blue_pin2, green_pin2, 0, 0, 0);
      delay(off_time);
      Serial.println(i);
    }
    RGB_color(red_pin1, blue_pin1, green_pin1, 255, 0, 0);
    RGB_color(red_pin2, blue_pin2, green_pin2, 255, 0, 0);
  }
  else {
    RGB_color(red_pin1, blue_pin1, green_pin1, 0, 0, 0);
    RGB_color(red_pin2, blue_pin2, green_pin2, 0, 0, 0);
  }
}


BLYNK_WRITE(V2) //Uncertainty
{
  int pinValue = param.asInt(); // assigning incoming value from pin V1 to
a variable
  // You can also use:
  // String i = param.asStr();
  // double d = param.asDouble();
  Serial.print("V2 value is: ");
  Serial.println(pinValue);

  if (pinValue == 1) {
    RGB_color(red_pin1, blue_pin1, green_pin1, 255, 0, 40);
    RGB_color(red_pin2, blue_pin2, green_pin2, 255, 0, 40);
  }

  if (pinValue == 2) {
    RGB_color(red_pin1, blue_pin1, green_pin1, 255, 0, 15);
    RGB_color(red_pin2, blue_pin2, green_pin2, 255, 0, 15);
  }

  if (pinValue == 3) {
    RGB_color(red_pin1, blue_pin1, green_pin1, 255, 0, 5);
    RGB_color(red_pin2, blue_pin2, green_pin2, 255, 0, 5);
  }

}

BLYNK_WRITE(V3) //All Good
{
  int pinValue = param.asInt(); // assigning incoming value from pin V1 to
a variable
  // You can also use:
  // String i = param.asStr();
  // double d = param.asDouble();
  Serial.print("V3 value is: ");
```

```
  Serial.println(pinValue);

  if (pinValue == 1) {
    RGB_color(red_pin1, blue_pin1, green_pin1, 0, 0, 255);
    RGB_color(red_pin2, blue_pin2, green_pin2, 0, 0, 255);
  }
  else {
    RGB_color(red_pin1, blue_pin1, green_pin1, 0, 0, 0);
    RGB_color(red_pin2, blue_pin2, green_pin2, 0, 0, 0);
  }

}

void setup()
{
  // Debug console
  Serial.begin(9600);
  pinMode(red_pin1, OUTPUT);
  pinMode(blue_pin1, OUTPUT);
  pinMode(green_pin1, OUTPUT);
  pinMode(red_pin2, OUTPUT);
  pinMode(blue_pin2, OUTPUT);
  pinMode(green_pin2, OUTPUT);
  Blynk.begin(auth, ssid, pass);


}

void loop()
{
  Blynk.run();
}

void RGB_color(int redPin, int bluePin, int greenPin, int red_light_value,
int green_light_value, int blue_light_value)
{
  analogWrite(redPin, red_light_value);
  analogWrite(bluePin, green_light_value);
  analogWrite(greenPin, blue_light_value);
}
```

Appendix H - Personal Reflection

During the last semester of my bachelor Industrial design I performed my Final Bachelor Project. It has been performed individually. This project has been both a way to show my skills that I developed throughout the bachelor, as well as to develop new skills. Moreover, it contributed to how I developed and keep developing as a designer in terms of my professional identity and vision.

Even though the Future Mobility Squad was my second preference for my Final Bachelor Project, I am happy I was able to design for this squad. Autonomous cars have always been of interest, and the topic "make users trust the automated car" which I designed for, suits my vision in terms of making knowledgeable design such that, in this case, it supports trust and makes sure users want to use the technology.

My aim for the project was to show my skills, especially in expertise areas which I developed in most throughout the bachelor and which I felt most comfortable in to use. These are User & Society, Technology & Realization and also Math, Data & Computing. This would make sure I eventually created a design that I could be proud of. However, to develop myself in the other 2 expertise areas, Creativity & Aesthetics and Business & Entrepreneurship, I wanted to develop skills within these expertise areas in the project as well.

Throughout the project, several steps have been performed in which I showed my skills and learned new knowledge:

At the start of the project I performed a literature study. This resulted in making design decisions in the use of specific information that would be shown in de final design. This literature study shows my professional skills in Dealing with Scientific Information. It showed that as a designer, I am able to apply knowledge gained from scientific literature.

To receive information from future users, a survey as was used. By using the skills in Math, data & Computing I analyzed the results and made graphs to show differences in demographics. Moreover, the mean mode and median as well as the standard deviation of all results were calculated. During My B3.1 I have finished courses in statistics. Therefore, the survey provided me with the opportunity to show these skills which I extensively developed during that semester.

In one of the iterations including the elements, I had my own perception about how the elements would show information. However, throughout the bachelor I have learned that design must be intuitive to use. Therefore, brainstorm sessions were held such that users could mention what they would perceive as intuitive. It showed me that by going to the user before making design decisions is a different approach I can also take in future projects. Moreover, by asking what would be intuitive for the user, I am making sure the design is knowledgeable for future users and the design thus adheres to my vision. Setting up these brainstorm sessions as well as performing them shows my skills in User & Society. Furthermore, analyzing these results using a qualitative content analysis also shows my skills in Math, data & Computing.

One of the expertise areas in which I really wanted to show my skills was Technology & Realization. At the start of the project I knew this was going to be difficult since it was too ambitious to create and especially realize a whole new dashboard without the required expertise and within the time limit. This became even more difficult when the idea emerged of a big OLED screen covering the whole dashboard. Eventually, a prototype was made that shows the looks and working of the elements if they would have been integrated in a dashboard.

Making this prototype has been both a way to show my skills as well as to learn new skills within Technology & Realization. The RGB LEDs that are used in the prototype are controlled via a mobile application in the context of Internet of Things. I am familiar with programming for Wifi boards such as an ESP8266 which was used. However, I challenged myself in using a new way to use this board which I was not yet familiar with. This has been the Blynk mobile application to control Wifi boards. Learning how to code for, and also use, the Blynk application will also create new opportunities for using this in future projects.

The making of the prototype also contributed to learning new skills in Creativity & Aesthetics. In the group projects throughout the bachelor, others have made the high-quality prototypes. Since the Final Bachelor Project has been individual, it has been a challenge to eventually make a high-quality prototype by myself. While making the prototype, I learned by doing. For instance, how to realize an aspect of the prototype in an easier way. This showed me that as a designer, I should sometimes just start doing, instead of reasoning about how to realize a design.

The above paragraphs mainly describe what I have done and how I applied my skills. They also include small aspects I learned in each one of them. One larger aspect which I learned in applying my skills, is how to apply them in a different context. As an example, I was already familiar with Wi-Fi-boards because I learned these skills when applying them for a product in the home. In this project I have applied these skills in a concept for an automated car. As a designer I learned to see new ways in how to implement my skills in different contexts.

Another larger learning point is new skills in the expertise area of Creativity & Aesthetics. i developed new skills in graphic design. A couple of times during the project I sat together with a fellow student who is proficient in graphic design. He thought me new features in programs such as Adobe InDesign and Illustrator. He also taught me that graphic design is also making small changes and comparing all outcomes. This led to the logo exploration and eventually to the logo of the ITE system which I am very proud of.

The most important, but also unexpected aspect I learned throughout the project however, cannot really be defined in one of the expertise areas, but more towards my overall development as designer. At the start of the project, I was very ambitious and eager to create a super high-quality design and prototype. I also wanted the prototype to work as how it would do so as much as possible. Keeping this ambitious result in mind caused me to be stuck in the process towards it. The feedback I received was to focus on smaller aspects of a larger design. By investigating these smaller aspects through for instance user testing, it will eventually come together in a larger final design. This mindset has been very important towards the final result of ITE and will be of benefit to keep in mind during future projects. By having this mindset, it makes sure I will be provided with the necessary insights and way of working to gain a clearer sight on my way towards a final design.

If I would redo the same project with the knowledge I have now, I would start earlier with investigating these smaller aspects of the design. In that way, more aspects could have been investigated which would only improve the final design of the ITE system. Moreover, I would have had time to create a motor-controlled prototype instead of manually using wooden sticks. In that way I could have learned more new knowledge in Technology & Realization.

Now that the project is finished, I can say I am happy with the result. I have been able to show my skills in various expertise areas as well as to learn new skills in others. Throughout the project, I also noticed that talking about the design and sharing the knowledge I gained is something I am interested in. Therefore, I oriented myself in doing a double master with Industrial Design and Science Education and Communication (SEC). The SEC master will provide me with the right knowledge in how to communicate and share knowledge such that it is understandable for everyone. This double master will also contribute to my vision and identity, as well as my own development as designer.