C.U. Driver

Outer UI for autonomous public transport.

-How will we communicate when there is no one to communicate with?

Lund University

Petra Renström

C.U. Driver - Outer UI for autonomous public transport

Degree Project for Bachelor of Fine Arts in Design, Main Field of Study Industrial Design, from Lund University, School of Industrial Design

Department of Design Sciences

Author
- Petra Renström

Examiner
- Claus-Christian Eckhardt, professor, designer.

Supervisors
- Claus-Christian Eckhardt, professor, designer, director of studies.
- Anna Persson, lecturer, designer.
- Charlotte Sjödell, senior lecturer, designer.
- Jasjit Singh, professor, designer.

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Abstract

With the advent of autonomous vehicles (AV) comes a plethora of new parameters to take into consideration in automotive design. Over the years, traffic signals and rules have developed in symbiosis, and are clear and easy to understand when the communication is between drivers. It is less clear between driver and pedestrian, especially when a pedestrian intends to cross the street. A non-verbal agreement is made as to who is allowed to proceed. With AVs, the driver will become obsolete, and pedestrians will have no means of communicating with the vehicle.

This project explores the possibility of applying an outer User Interface (UI) for autonomous vehicles, by looking at past paradigm shifts in technology, and analysing traffic signs and signals on a global scale. Limitations with this project lies in the local traffic signal variations, as well as physical variations in vehicles, as these would affect the layout and final form of the UI. With this in mind, I have chosen to focus this project on buses in public transportation.

The main objective of the project is to reassure the pedestrian of their safety. In summary, the core of this project explores the concept of autonomous vehicle outer UI - one that can be adapted to situational and regional deviations, using both soft- and hardware.

Recognition

Great thanks to everyone who took the time to help me with my thesis. I am infinitely grateful for the time you have taken from your busy schedules. Your interviews have built this project and have been vital to the process and to the resulting conclusion. Thank you:

Lisbeth Harms, Carina Dahllöf, Anita Herlitz, Caroline Carlstedt,
for referrals to the right people.

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for insights into human behavior.

Lars Medegaard Schelde,
for defining cultural difficulties.

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Anders Lundqvist Persson,
for all the food.

Flip to see animation

Simplified version

The result of the project is an animation. The animation has over 300 frames, divided into four stages; Drive, Detect, Act, and Stand-by. To fit the animation on 75 pages, I've removed every other frame (going from 24 fps, to 12 fps) and the "pauses" between stages. These pauses would set the tempo in a real setting, but as a flip animation, would not contribute to the experience.

Drive

8_INTRODUCTION /

This chapter contains motivations and the background for early decisions made in the project. It lays the foundation for the direction taken throughout this thesis.

INTRODUCTION /

BACKGROUND

I don't like cars

A car has four wheels that go "vroom". This would be the level of interest I had in cars, prior to this project. And an autonomous vehicle (AV), was to me just a new kind of car.
What opened my eyes was my internship at a design consultant agency in Japan. The CEO and I held a workshop with Honda and their research and development department. I was captivated by the **experience** of autonomous vehicles, and the possibilities that arise with this new kind of mobility.

Key - Semcon's smiling car concept

Semcon is working to solve the lack of communication between car and pedestrian. Their smiling car concept has been key in this project. They've identified a clear problem area for AVs, and have solved the lack of feedback, by re-introducing a bit of humanity. It is a charming project that captivated my interest.
Together with research institute Viktoria Swedish ICT and partners in the automotive industry, they base their design on human behaviour. And with this, allowing pedestrians to communicate in a way that they are used to - with facial expressions ("The Smiling Car - Who sees you when the car drives itself?". (n.d.)).

INTRODUCTION /

MOTIVATION

Adapting to the new

Semcon's concept of the smiling car, got me interested in the direct relationship between people and AVs. The concept explores the possibilities of communication with pedestrians, when there is no driver to communicate with. This concept highlights new challenges that we will be facing in our current time period; namely, the transition period. People are adapting to new technology, and technology is adapted to people.

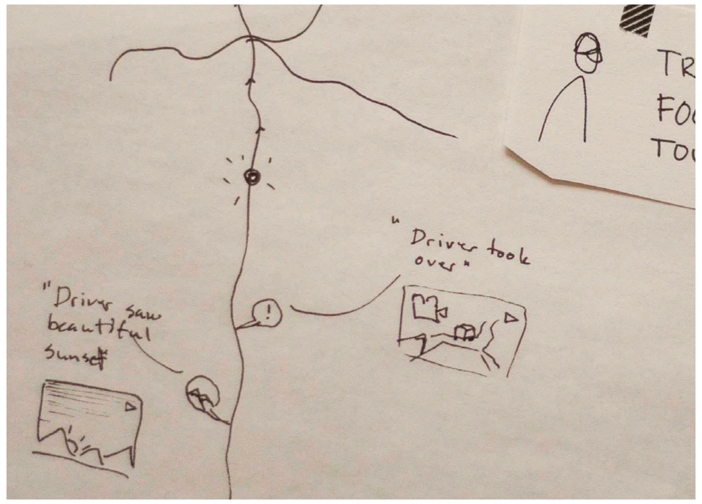
This reminded me of what I have learned of past transition periods, and how people solved the alien feel to the new technology then. The steam-engine with a horse figure head, early cars with lavish sofas and crystal light fixtures. Keeping some of the old to slowly adapt to the new.

Creating trust

Whenever I have spoken with people about AVs, they will, without fail, bring up the adapted version of the Trolley Problem. It is a thought experiment in ethics, in which you are a bystander to an inevitable tragedy, where people are bound to the tracks, and you have the option to pull a lever and choose which tracks the trolly will take. In the adapted version, it is people on a crossing, and the vehicle will have to choose who to run over; the grandma, the baby, or hit the road block and kill the passenger?

Trust in new technology comes with exposure over time. This is doubly relevant when the technology's missteps can end in fatalities. By reading news, and listening to people discuss AVs, I got the impression of a general lack of trust for the technology. The term "driverless" is frequently used, and inherently conveys that the vehicle is inadequate. Creating trust has therefore been a central motivation in the project.

One early idea I had was to live-stream half-autonomous trucks and their drivers. My reasoning was that by being transparent with when the driver takes over the wheel, and why, this would create an understanding of the capabilities (and limitations) of AVs. This would mean exposure over time and creating trust. Even if I chose to not go forward with this idea, the trust have been central in the project.



Early idea. Live streaming a half-autonomous vehicle and driver.

Detect

INTRODUCTION /

DEMARCATIONS

Crossings

I've chosen to focus on the crossing in this project. At crossings with no stop lights, pedestrians largely look at the vehicle and for eye-contact with the driver, to gauge if it is safe to cross. With no driver, pedestrians are left to make their judgment from only the vehicle, and whether they can trust it to stop.

To cross the road, means to cross paths with vehicles that can easily kill you. Which is why the crossing may prove to be crucial in the acceptance of autonomous vehicles.

Transition period

The period from no driverless cars, to a fully AV adapted society. We are in the transition period, and new insights and discoveries are constantly being made. It is a great opportunity to shape the future of autonomous mobility and make the transition into a smooth one.

I want to still the fears that people might have here and now. What might seem frightening now, will be a thing of the ordinary in the future. This means that my findings and solutions, might only be relevant for us until we have adapted.

Buses in public transportation

Personal vehicles are marketed and made for the individual who will be driving them. The focus in form and function therefore lies with the person inside. Public transportation is made to be used by everyone, and autonomous public transport also have to be accepted by everyone, including those outside of the vehicle. Cities will have a higher standard for the security of their citizens, and I thought that this would be a good place to start.

Visual element

Direct communication between driver and pedestrian is largely made with eye-contact. Since both are interpreted with sight, I have chosen to focus on a visual solution. This is a start, and can later be enhanced with auditive and/or other signals.

UX/UI

The project has been driven by how the pedestrian would experience a safe crossing. Which is why focus lies in the UX, UI, and motion design. What I did in terms of hardware was researching possible solutions, and what might be suitable for my solution. The technical aspects will have to be tested in a real setting at a later time.

Horsey Horseless, 1899.

Detect

16_RESEARCH /

In this research heavy project, I compared the experiences of the past, to our situation today. I talked to experts in different fields of autonomous driving, and got their valuable input on how things may progress.

Detect

RESEARCH /

HISTORY

Past paradigm shifts in technology and public reception. How did people overcome fast technological advancements, and can we draw paralells to today?

Chicago, ca. 1911. Full-length portrait of Charles Moore, elevator operator at Cook County Hospital, located at 1835 West Harrison Street in the Near West Side community area of Chicago, Illinois, standing in the open entrance to his elevator. DN-0056446, Chicago Daily News negatives collection, Chicago History Museum. Retrieved March 17. 2018. From http://chsmedia.org:8081/ipac20/ipac.jsp?profile=

Elevator operator

A profession of the past.

Riding an elevator was a much different experience in the past (Newman, A. (February 12, 2018). Riding a Time Capsule to Apartment 8G. Retrieved June 19, 2018, from the New York Times.). Elevators were operated by a lever which controlled the elevator car's speed and direction. An elevator operator was in full control, and would align the car to the floor and give the passengers a smooth ride. There were two improvements to the machinery that ultimately rendered the elevator operator obsolete. The first one was the self-levelling mechanism, allowing the elevator to align itself automatically to the floor. The second improvement was when Otis perfected the push-button system in 1950. The elevator no longer demanded a chauffeur to be operational, and the company boasted that the system "minimizes the human element", (Newman, 2018).

To this day, there are still elevators that require an operator. In New York, these are old relics, where some of them have operated since before the introduction of floor buttons. The reason for them being operational varies. In apartment-complexes, the operator can bring a personal touch, and also serve as extra security. Other elevators might be limited in dimension, and the elevator's proportions simply does not allow for an upgrade.

Allegedly Phoenix 1904, north-west corner of Washington and 1st Avenue.

Bans and restrictions on “reckless motorists”

The famous Red Flag law was passed by the British parliament in 1865. It stated that automobiles was allowed a maximum of 2 mph (3.2 km/h) in town, and 4 mph (6.4 km/h) in the country side. The vehicle had to be preceded by a man on foot, waving a red flag, to warn passersby - hence the name of the law. It was not repealed until 1896.

Restrictions like this were common at the first arrival of automobiles. New technology that was both loud, dirty and dangerous, was a threat to society and its use had to be restricted. Early motorists were of a higher class that could afford this new technology. Which allowed the upper class to take refreshing tours out in the countryside. But from the farmers' side, the automobiles brought to their calm life strangers, who polluted the air and disturbed the silence. Fowl and farm dogs would fall victim to the roaring automobile, who's wealthy driver had no understanding of the impact the loss of a chicken could have on a rural household.

Over time, the peasants' resentment towards the motorists grew to hostility, and the motorists' scorn grew to fear. Rock-throwing, assault and road traps were not unheard of, and motorists were recommended to bring a firearm with them when visiting the countryside. (Ladd, B. 2008, cited from "Autophobia: Love and Hate in the Automotive Age by Brian Ladd, an excerpt". (n.d.), The University of Chicago Press.)

Horseless carriage

"The noble horse, despite all its virtues, still stupider than a motorist, remains untouchable, although it has been proved a hundred times that horses and horse-drawn wagons cause more accidents than automobiles."

-Excerpt from a German motor journal (1904), lamenting over the press' tendency to refer to "automobile accidents". (Ladd, 2008)

Google car, 2014.

Driverless car

"The human, despite all its virtues, still stupider than a computer, remains untouchable, although it has been proved a hundred times that people and conventional cars cause more accidents than self-driving cars."

-Could have been an excerpt from a motor journal (2018).

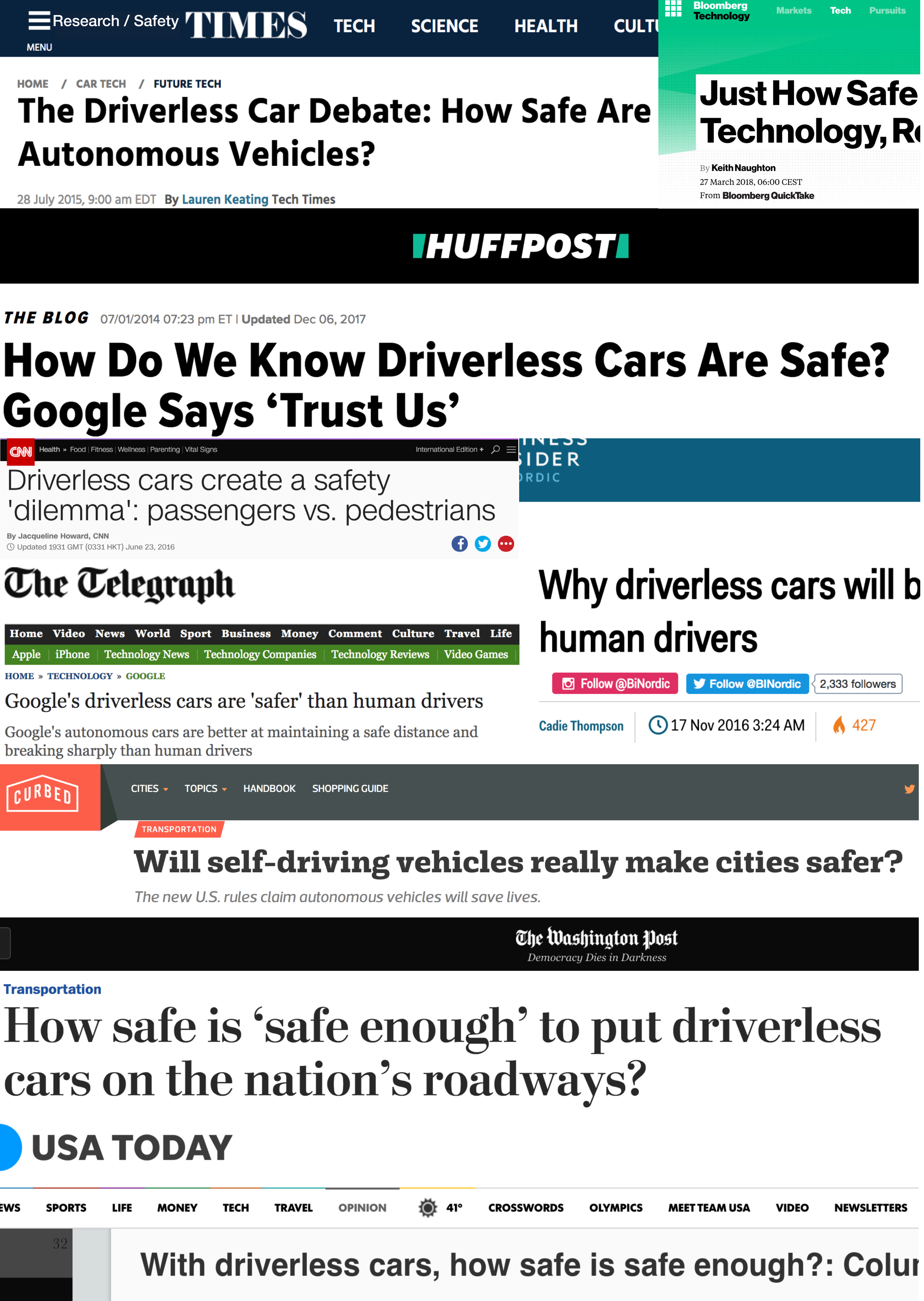
HISTORY /
KEY INSIGHTS

Safety is a major concern in large technological paradigm shifts.

RESEARCH /

SAFETY

Perceived vs. actual safety. How is it portrayed in media and what are the actual facts?



The "Safe Debate"

History repeating itself

Safety is, and should be, the focus of the development of autonomous driving. But even so, as long as the laws of physics still apply, autonomous vehicles will be in accidents. But as in the past, the press have a tendency to write headlines that put the blame on the vehicle rather than the circumstances, or the humans involved.

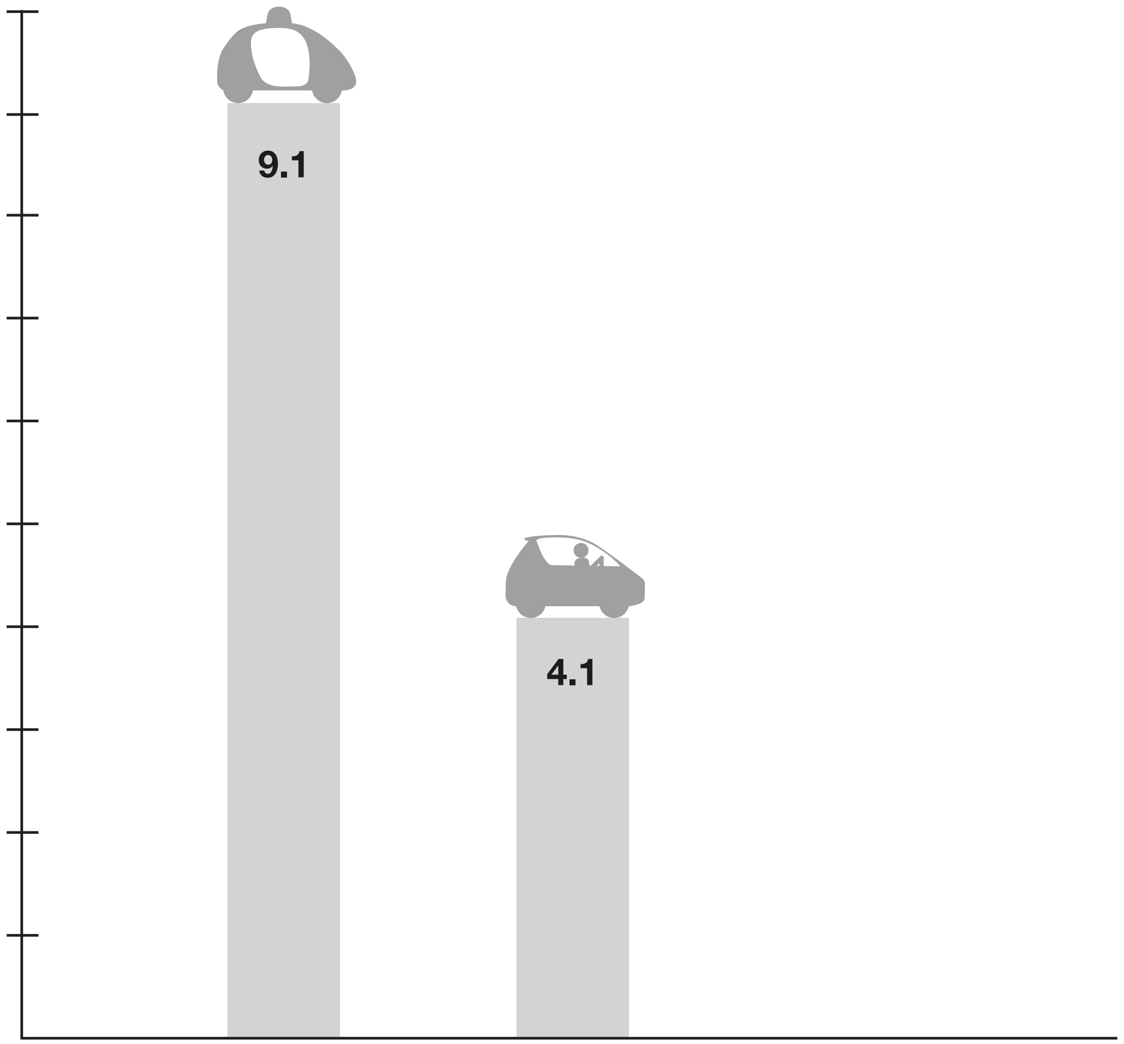
Detect

Autonomous vehicles more often in crashes

According to a study by the University of Michigan Transportation Research Institute.

The study gathered data between 2012 and 2015 from Google, Delphi and Audi's autonomous car projects. They, along with Tesla, Honda and BMW, are required to report any accidents they are involved with in California. There is an average of 9.1 crashes per 1000 000 miles for the autonomous cars. This is more than double that of conventional cars, which have an average of 4.1 crashes. The USA National Highway Transportation Safety Administration estimates that 60 percent of property damage-crashes, and 24 percent of person injury-crashes, goes unreported each year. The study concluded that the data is limited, and that in actuality, conventional cars might have a much higher accident rate.

Accidents per 1000 000 miles

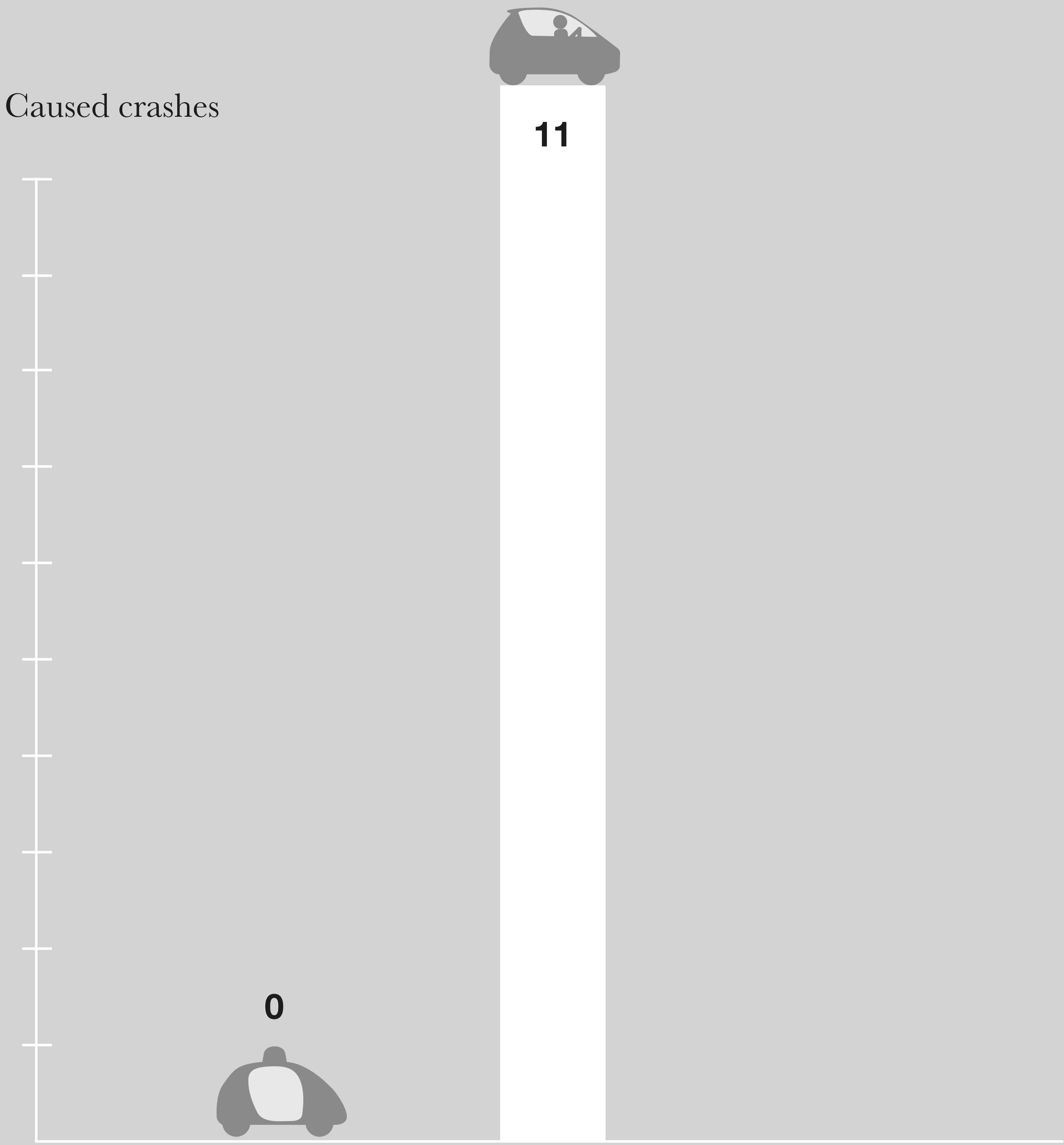


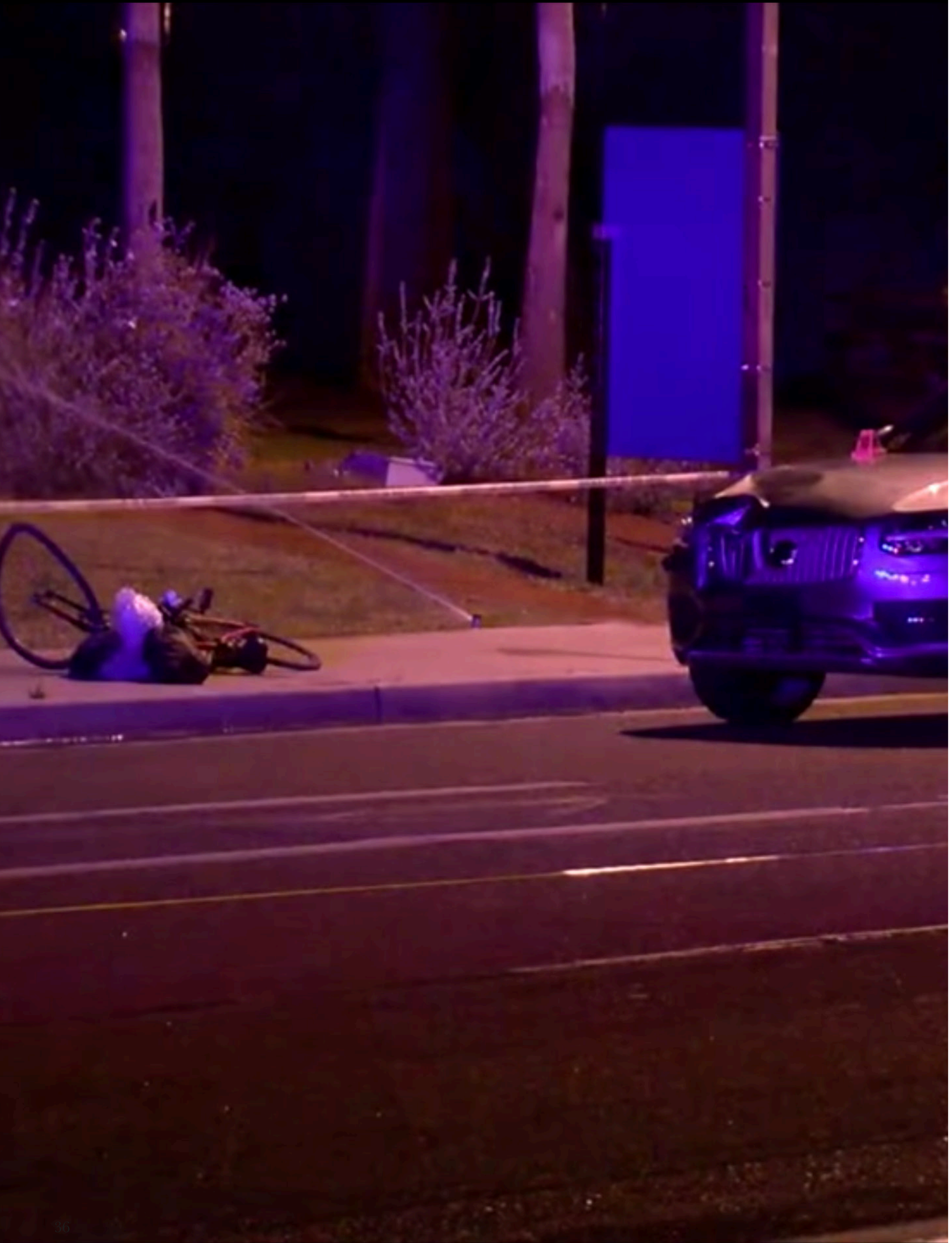
Crashes are caused by other drivers

Relatively harmless accidents.

Whilst the autonomous vehicles appears to be in more crashes than regular cars, the accidents themselves are relatively harmless. In 8 out of 11 crashes, the vehicle was either standing still, or moving in less than 5mph. A common accident involves being rear-ended by another vehicle when standing still at a stop sign. (LeBeau, P. (October 29, 2015). Autonomous car crash data may not tell whole story. CNBC.).

Caused crashes





First fatal accident caused by an autonomous car?

A car of Uber's test-fleet hit a pedestrian walking her bicycle across the street.

On march 18, 2018, the race to be the first on the market claimed its first victim. In an unfortunate accident, a test-vehicle struck and killed a pedestrian crossing with her bicycle in Tempe, Arizona. The testing was conducted with a safety-driver behind the wheel, who is there to take over if needed. This is one type of testing that several companies are applying to their programs. Initially, it appeared as if the vehicle completely failed to pick up on the woman's presence, since it did not react by braking, slowing down, or alerting the driver.

However, according to the police report, the vehicle did register the pedestrian a whole 6 seconds before impact, and at 1.3 seconds, deducted that it needed to apply the brakes. The vehicle was in autonomous mode at the time, but to "reduce the potential for erratic vehicle behaviour", the system used to automatically brake in a potentially dangerous situation, had been disabled. Instead, the vehicle relied on the human backup driver to apply the brakes in case of an emergency. However, the system is not designed to alert the driver, putting all of the responsibility on the person behind the wheel.

According to Alain Kornhauser, faculty chairman of autonomous vehicle engineering at Princeton University, it is likely that Uber determined that the system braked in situations it should not have. For objects such as overpasses, signs and trees. Kornhauser said that the system got "spoofed too often", and "instead of fixing the spoofing, they fixed the spoofing by turning it off".

There are several factors that would have made the situation difficult for a human driver. Firstly, the test-driving was conducted during dark, which is the reason the driver did not see the victim until collision was imminent. The pedestrian crossed where there were no crossing and no streetlights. She wore dark clothes and her bicycle's wheels did not have any side reflectors, leaving only the front and back that were perpendicular to the road.

The U.S. National Transportation Safety Board (NTSB) report that the system determined that it needed to break at 65.6 feet (approx 20 meters) from victim, and was traveling at 39 mph (approx. 60 km/h) at the time of impact. The safety-driver did in fact take control of the wheel slightly after that. But did not push the brakes until after less than a second after impact.

(Anonymous. (May 24, 2018). "NTSB: self-driving Uber in AZ spotted pedestrian 6 seconds before fatal crash". ABC7 Los Angeles. Retrieved June 18, 2018, from http://abc7.com/)

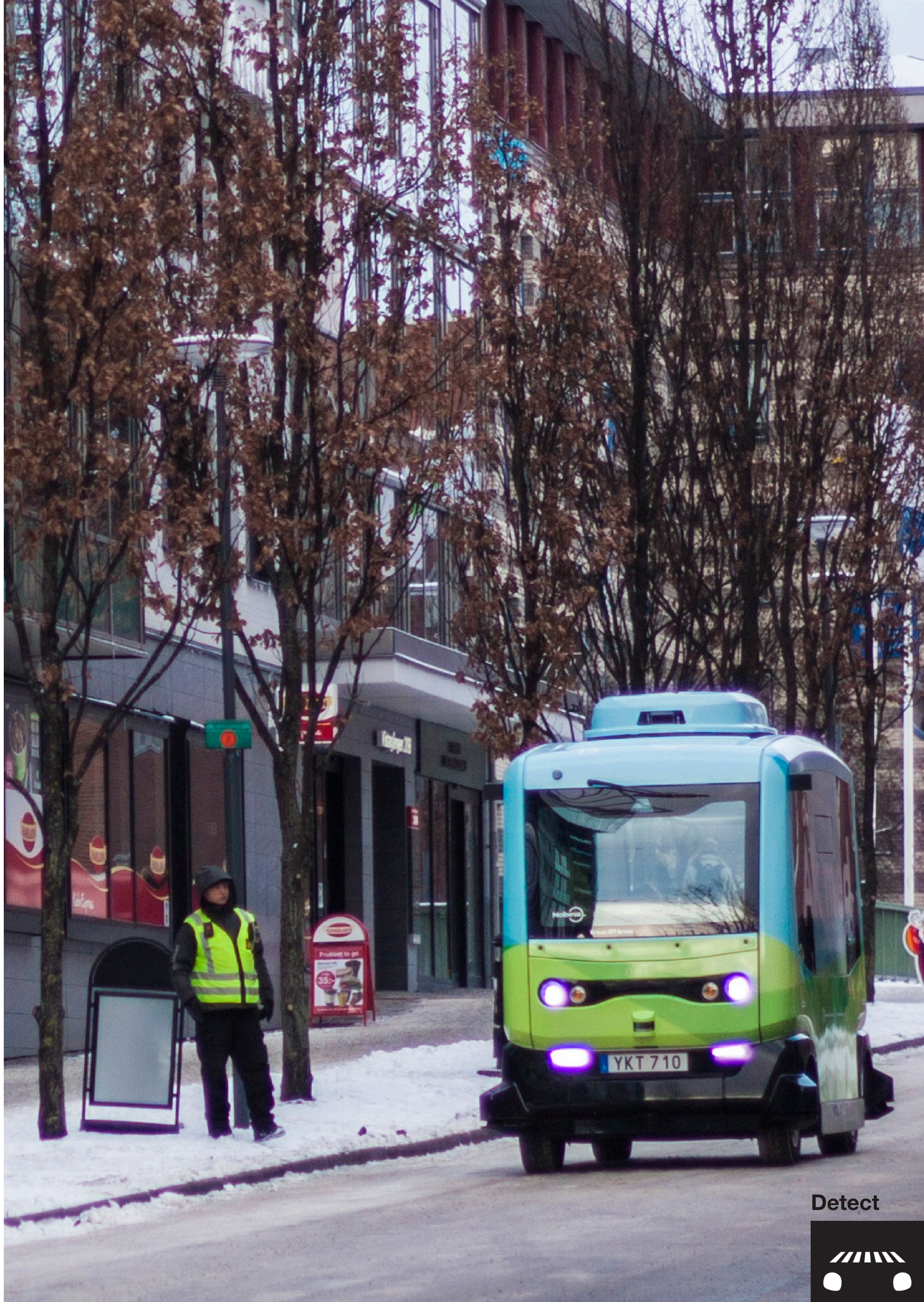
SAFETY /
KEY INSIGHTS

Regardless of the *objective safety* of AVs, *distrust in the technology* is prevalent.

RESEARCH /
KISTA CASE STUDY

In the spring of 2018, I visited the self-driving bus that was in operation between Kista Galleria and Victoria Tower. The bus was running to gather data for different actors, and to evaluate how the public responds to the vehicles. This is one of the first steps to actualize autonomous public transport in Stockholm, even if it might yet be some time before they are adopted into the existing transportation system.

- 6 seats
- 6 standing
- Max speed 11 km/h
- Bus host



Screen that shows the vehicle's status.

Control for the host who can "take over" if needed.

Large buttons for exiting and two alarm buttons.

Overcompensating safe semiotics

Safer than it "needs to be".

The bus has an exceptionally strong semiotic language when it comes to safety. Passengers are overly assured that the bus is safe by big buttons and large controls. The speed at which it moved was also adjusted to confirm that it can not cause any accidents. It also took the safest option at any given situation, as it should, although it made the bus seem dumber than it actually is.

Cameras are installed on the outside

Their only function is to calm the passengers.

Passengers were questioning whether the vehicle was actually picking up on its surroundings. After cameras were installed, that worry drastically dropped. The cameras are in no way connected to the vehicle's actual navigation system, but it enables the passengers to visualize how the bus orients itself.

KISTA CASE STUDY /

KEY INSIGHTS

By showing that the AV sees, distrust towards the AV's navigation capabilites was quelled.

Detect

RESEARCH /

INTERVIEWS

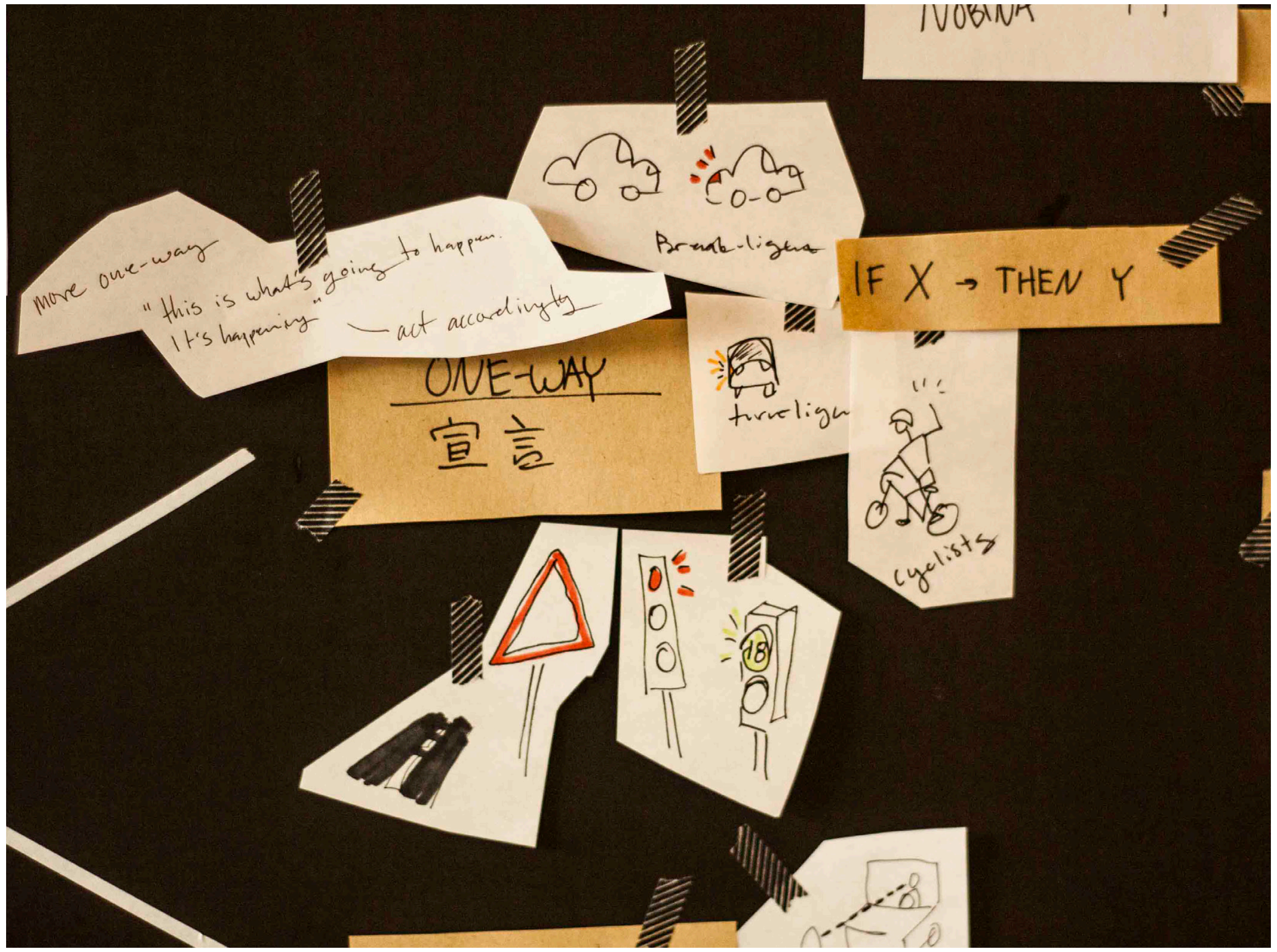
I interviewed four experts in different fields of autonomous driving. They each had valuable insights into the various aspects that are dictating the development in the adaptation of AVs.

Anette Jerup Jørgensen,
(at the time of interview) post doctorate at Aalborg University. PhD thesis on the actions of the driver between legal norms and practice.

Lars Medegaard Schelde,
director of Moving Spaces IVS: an architectural consultant agency with focus on sustainable mobility and urban planning solutions.

Anna Haupt,
Acting Vice President Product Strategy & Planning at NEVS. Founder of Hövding, the airbag bicycle helmet.

Claes Herlitz,
Vice President Global Automotive Services at Ericsson.



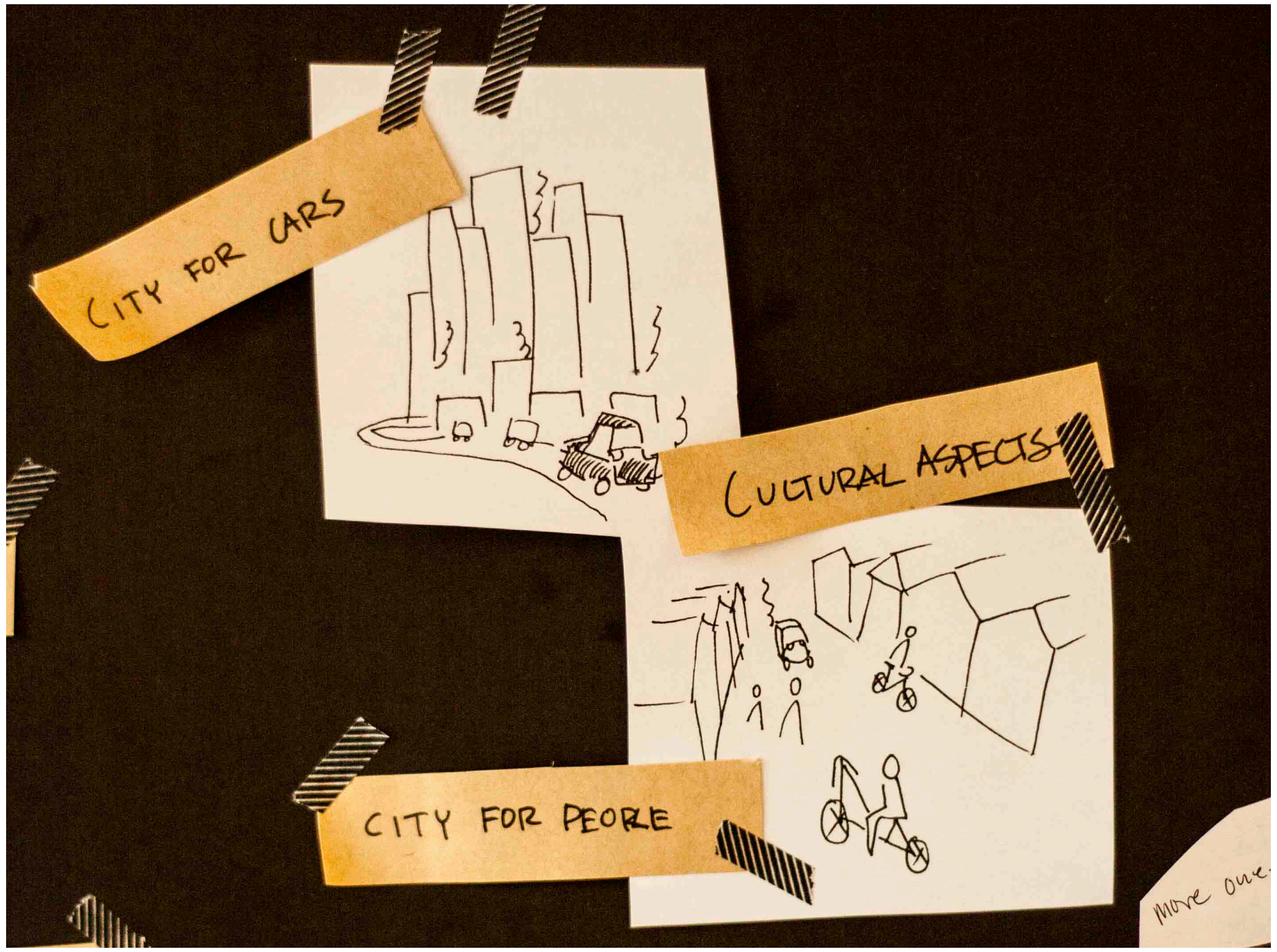
“Unlike people, AVs will drive by the book”

Anette Jerup Jørgensen, post doctorate at Aalborg University. PhD thesis on the actions of the driver between legal norms and practice.

I got in contact with Anette Jerup Jørgensen, who is currently conducting her post doctorate at Aalborg University. Her PhD thesis analyses the social factors of Danish traffic culture, and what role morals play in the context of following regulations. Her expertise gave me an insight into human behaviour in traffic, and also what role culture plays on the road.

According to Jerup Jørgensen, one out of ten drivers in Denmark, text whilst driving. And there are people that already use their car as their workspace, reading emails or checking papers in traffic. They know that what they are doing is wrong, but they justify this by only doing it on small roads, or when there are only few cars around. Autonomous driving will give these people time and space to do work, without endangering themselves or others.

In the transition period, the autonomous cars will follow traffic regulations, unlike human drivers, who also follow cultural rules on how to drive. The Danes have a tendency to be more lenient towards regulations, and Jerup Jørgensen says that the autonomous vehicles will most likely force them into a safer traffic flow. The autonomous cars will be programmed to take the safest action available when driving. This is unlike any human driver, who is prone to taking calculated risks. During the transition, when both autonomous and traditional cars are on the road, people will have to adapt to this safer style of driving.



"Pedestrians want to engage with the driver"

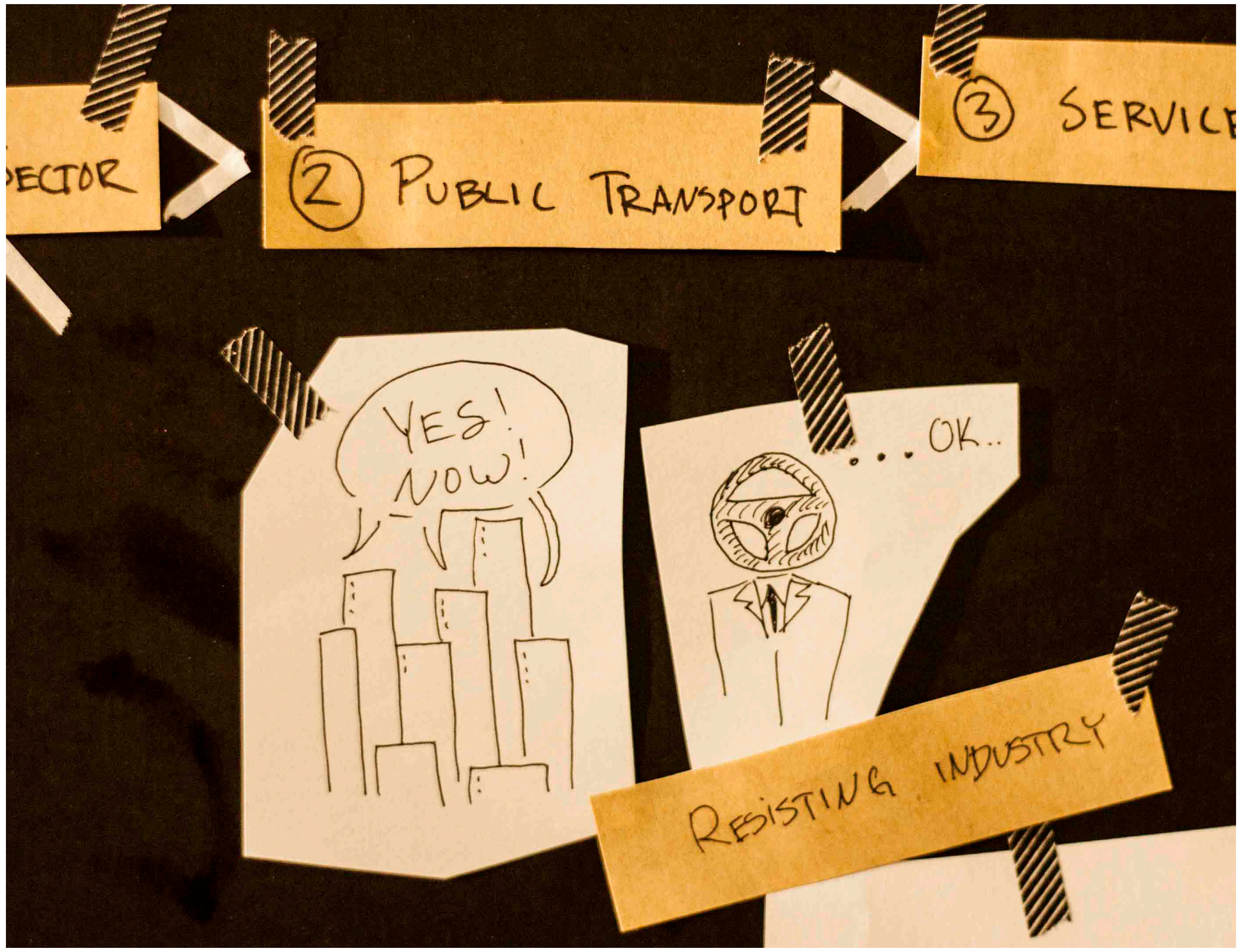
Lars Medegaard Schelde, director of Moving Spaces IVS: an architectural consultant agency with focus on sustainable mobility and urban planning solutions.

Medegaard Schelde's company puts emphasis on bicycle planning and behaviour in the future of sustainable urban mobility. During our interview, he gave me valuable insight into autonomous traffic, and its adaptation to roads frequently used by cyclists and pedestrians.

The testing of autonomous vehicles is mainly conducted in cities that were designed for cars, where there are few pedestrian crossings and the roads are straight. The weather is also favourable, since testing sites like Phoenix, Arizona have very little rainfall all year around. This allows the development to advance in close to ideal conditions.

Autonomous vehicles will come later to old cities, where the urban landscape is made for people on foot. There will be more factors to take into consideration, with pedestrians, bicycles and narrow streets. Not only that, the cultural aspects of traffic will be difficult for a computer to adapt to. Medegaard Schelde says that cyclists in Denmark are well trained in traffic rules and use hand signals most of the time when they intend to make a turn. But this is not the case in many other places, and the computer needs more intricate algorithms to be able to read the unreliable nature of humans.

Equally as important; how will a pedestrian read an autonomous vehicle's intended action? A study conducted by Semcon and Inizio (n.d), shows that pedestrians interact with drivers through eye-contact to confirm that they have been seen. How will people react when the source of feedback is removed? What are the consequences, and what can we do about it?



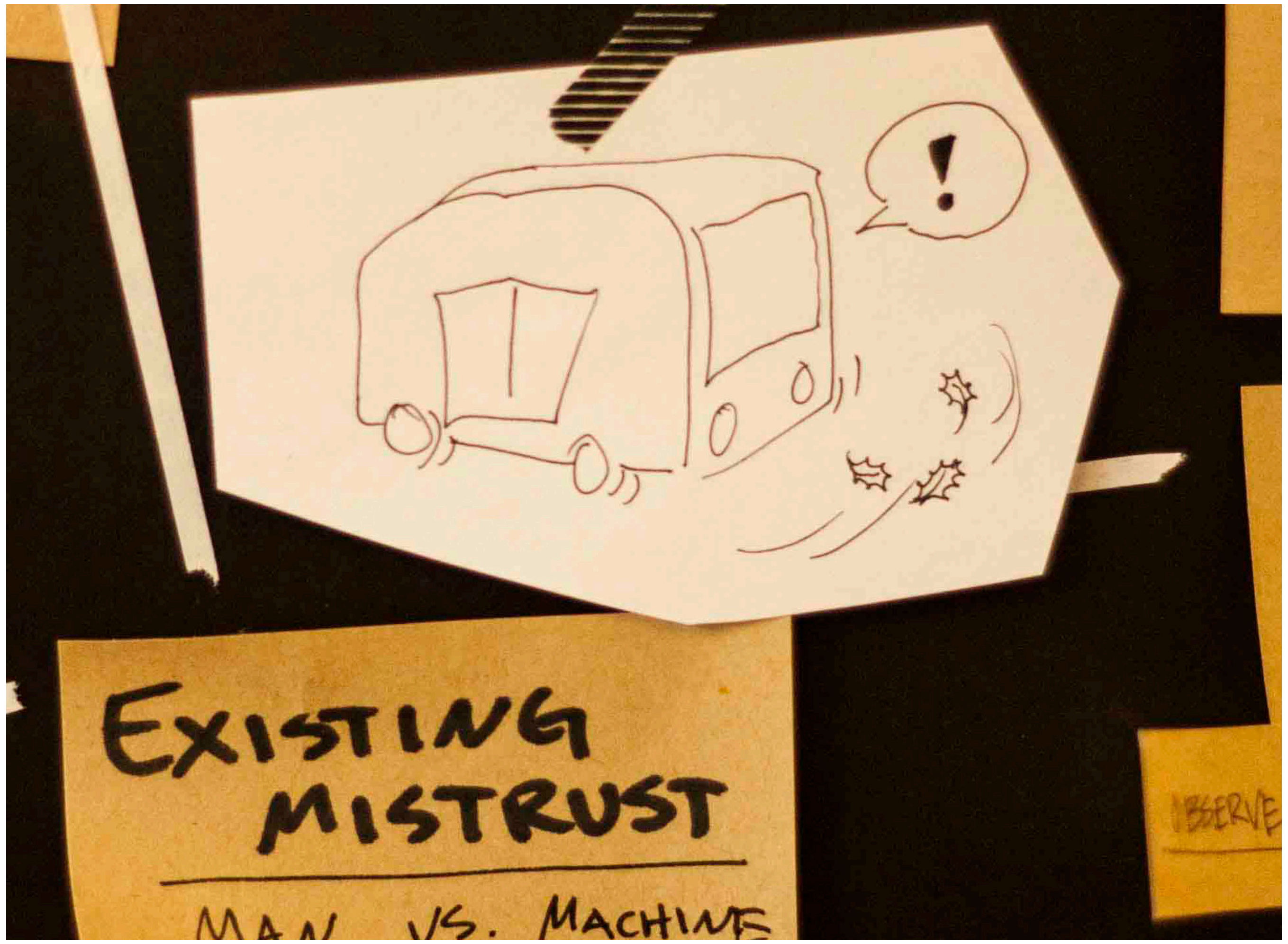
"The public wants autonomous cars. It is the industry that is resisting"

Anna Haupt, Acting Vice President Product Strategy & Planning at NEVS. Founder of Hövding, the airbag bicycle helmet.

Anna Haupt comes from a professional background outside of the traditional automobile industry. This gives her the advantage of being able to question the norms in the industry, and she graciously shared the observations she has made, and what we might be able to expect in the future.

According to Haupt, there is a cry for autonomous vehicles in bigger cities. Her interpretation of the situation today is that both the public and politicians want more efficient means of transportation within the city limits. A fleet of autonomous vehicles in urban areas can be tailored after a city's specific needs. It would be cost efficient, practical and decrease the need for individually owned cars. Land areas for roads and parking spaces can be scaled down, and air quality would improve with the lessened pollution from vehicles.

However, fewer cars means less profit for the car manufacturers. And Haupt concludes that it is the traditional industry that is not keen on this change, and is only letting the development to progress slowly. The ones pushing the progress forward are software developers. They are the ones that will gain the most by claiming this new market. The car industry will merely supply them with the "hardware", i.e. the car. The industry will adapt to society's wish for autonomous vehicles, but according to Haupt, there is no need for car manufacturers to be the first on the market, only the biggest.



“The pedestrians will look for eye-contact with the non-existent driver ... and then back away.”

Claes Herlitz, Vice President Global Automotive Services at Ericsson.

I got the opportunity to interview Claes Herlitz just shortly after his return from an automotive fair. His recent intense meetings with other companies in the industry, may have contributed to the diverse insights he imparted with me.

Herlitz says that there is a race amongst the software developers to be the first on the market. There lies a lot of focus on how to integrate autonomous vehicles with human drivers. Safety is the vehicle’s priority, but there might arise situations that are too complex for its current algorithm. According to Herlitz, If that happens, there is a high probability that the vehicle will simply stand still, rather than try something it has not been programmed for.

This is a dilemma that current testing is facing. Whilst test-driving, the vehicle is meant to gather data that will later be used to upgrade and improve its algorithm. Which is why it takes the safest option in every given situation. It is also important that the public views them as safe, since it would be devastating to gain a reputation of untrustworthiness whilst development is still ongoing.

A human would take a chance here or there, or lie too close to other cars on the highway, or hit the breaks a bit late when stopping at a red light. This behaviour from an autonomous vehicle would be completely unacceptable to the public. Test-vehicles are therefore programmed to err on the side of caution, and this extreme caution from the vehicle can make it seem dumber than it really is. So instead of appeasing the public, it can have the adverse affect by unintentionally implying that it is unfit for traffic.

“Pedestrians walk up to the curb and look to the bus to make sure that it has stopped. The bus won’t drive as long as someone is waiting to cross. The pedestrians will look for eye-contact with the non-existent driver, sometimes for several minutes, and then back away. Since there is no one to confirm that they have been seen, they get uncertain and uncomfortable with crossing.”

-Claes Herlitz, about a recurring curious situation with the self-driving bus in Kista.

INTERVIEWS /
KEY INSIGHTS

1. **“Unlike people, AVs will drive by the book”**
2. **“Pedestrians want to *engage with the driver*”**
3. **“The public wants autonomous cars. It is the industry that is resisting”**
4. **“The pedestrians will look for *eye-contact* with the non-existent driver ... and then back away.”**

At crossings, what happens when the interaction between driver and pedestrian is lost?

At crossings, eye-contact with the driver allows both parties to establish a mutual connection, and a non-verbal agreement can be made over who will pass. With a driverless car, this ritual and agreement can not be made. This may cause confusion and uncertainty in the pedestrian, who rely on this confirmation to feel safe in crossing.

My unwillingness to delve into this lied in the fact that I felt that this had already been solved with Semcon's smiling car. I did not want to steal an idea, yet I was charmed by the concept of retaining the humanity in the feedback. Claes Herlitz's recounting of the effect of the lost eye-contact, was confirmation that this is an area in need of development.

React

8 of 10 pedestrians seek eye-contact with driver*

What happens when there's no eyes to contact?

*The Smiling Car - Who sees you when the car drives itself? (n.d). Retrieved 15 march, 2018, from https://semcon.com/smilingcar/

Hypothesis

SEEN + SAFE = CROSS

A non-moving vehicle is not enough to convey safe crossing.
Pedestrians need confirmation that their presence has been detected to feel safe.

Brief

At crossings,

provide pedestrians with

visual feedback that;

1. The vehicle has registered your presence

2. It is safe to cross

66_ANALYSIS /

What makes crossings perceived as safe; what are the needs of the pedestrian, and what is the driver contributing with to their interaction? This chapter concludes what types of communication tools are used in traffic, and how it can be developed for this project.

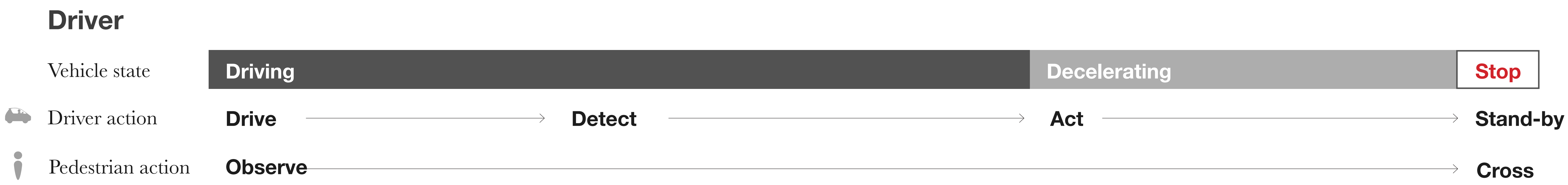
ANALYSIS /

JOURNEY

A user journey is a tool used in UX design. It can help visualise important factors from which insights can be made. This journey here shows the difference in interaction between pedestrian/driver and pedestrian/AV. This difference is key in re-instating a sense of familiarity in the pedestrian.

The journey of stopping

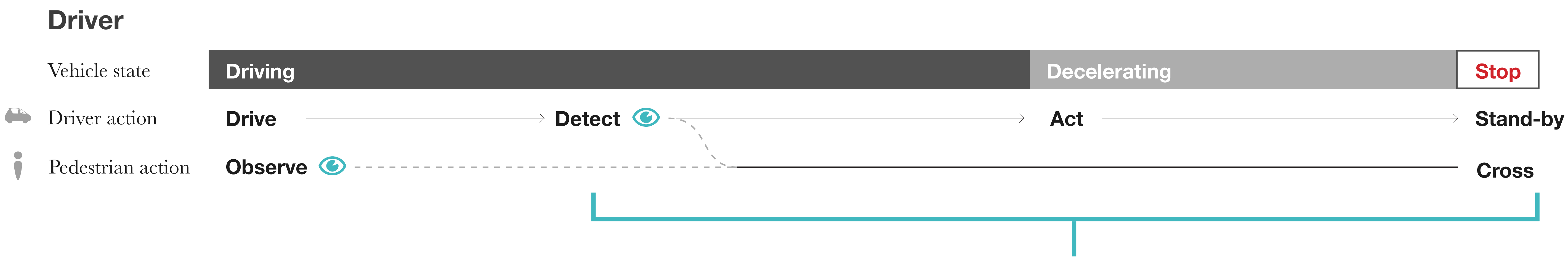
How a driver and pedestrian interacts at crossings. Visualising the journey* of stopping, the actions of the driver always occur in the order of; Drive, Detect, Act, and Stand-by.



(*This is a visualisation of an ideal journey, in the sense that the pedestrian makes the decision to cross when the vehicle is at full stop, and driver on stand-by. In a real setting, pedestrians can choose to cross at any given point.

Key elements:

1. See the pedestrian
2. Observe the pedestrian



Touchpoint - Eye-contact

My hypothesis is that eye-contact is key in making the pedestrian feel safe. The eye-contact starts when the driver detects the pedestrian, and ideally lasts until the pedestrian has crossed.

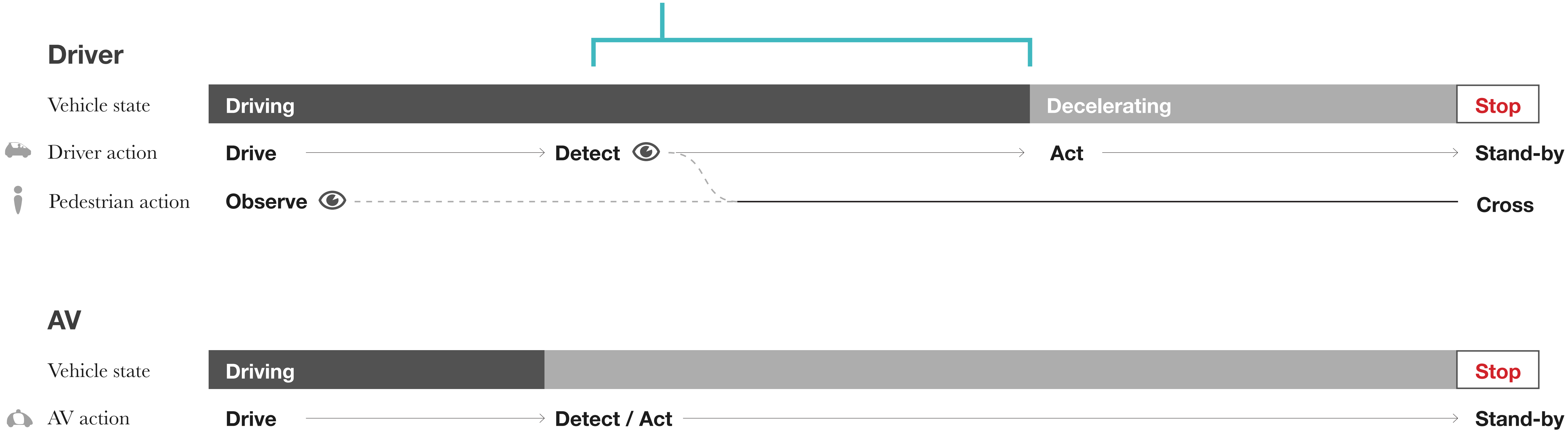
React

Key elements:

1. **See the pedestrian**
   - **1a. React to the pedestrian**
2. **Observe the pedestrian**

Human factor - Reaction delay

For any person, there is an inevitable delay between sensory input and taken action. Whilst this delay between Detect and Act, isn't part of my original hypothesis of seen+safe=cross, it does play a part in how to humanize the visualised response from the vehicle



A computer has a delay that is far to fast for any person to perceive. Which is why it is depicted as happening simultaneously.

(*This is a visualisation of an ideal journey, in the sense that the pedestrian makes the decision to cross when the vehicle is at full stop, and driver on stand-by. In a real setting, pedestrians can choose to cross at any given point.

AV lacks visual feedback

Have the AV communicate with the pedestrian.

I theorise that the lack of communication from the vehicle is one of the reasons why pedestrians may feel uncertain at crossings. My plan is to have the vehicle interact with the pedestrian, and perhaps do so in a manner that is recognisable for the situation. I want the AV to imitate a driver.

The two big differences between driver and AV; is the driver's eye-contact with the pedestrian, and the delay between Detect and Act. Showing the pedestrian that the AV can see them before it slows down, would imitate both the eye-contact and the delay between Detect and Act.

Driver

AV

React

JOURNEY /

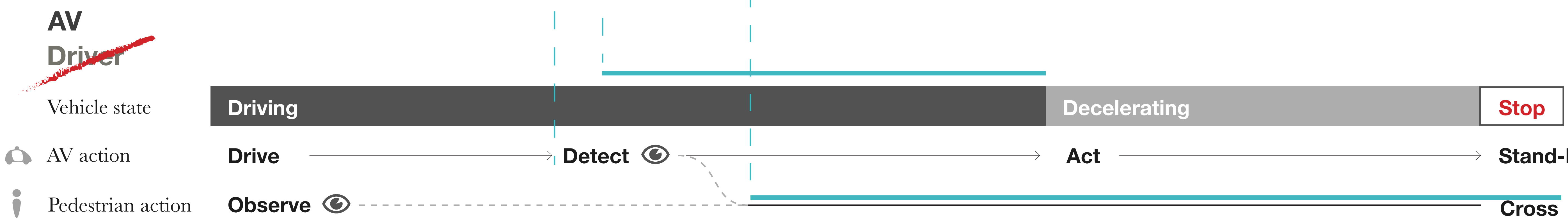
DECISIONS

AV should imitate driver mannerisms by communicating that it:

1. Sees the pedestrian

1a. Reacts to the pedestrian

2. Observes the pedestrian



React

ANALYSIS /

COMMUNICATION TOOLS

I've analysed different means of communication in traffic, and which might be suitable for conveying the messages in my brief; seen and safe.

Communication in context of traffic

What tools are used in traffic today, are there other tools, and can I use them to convey the message of “seen” and “safe”.

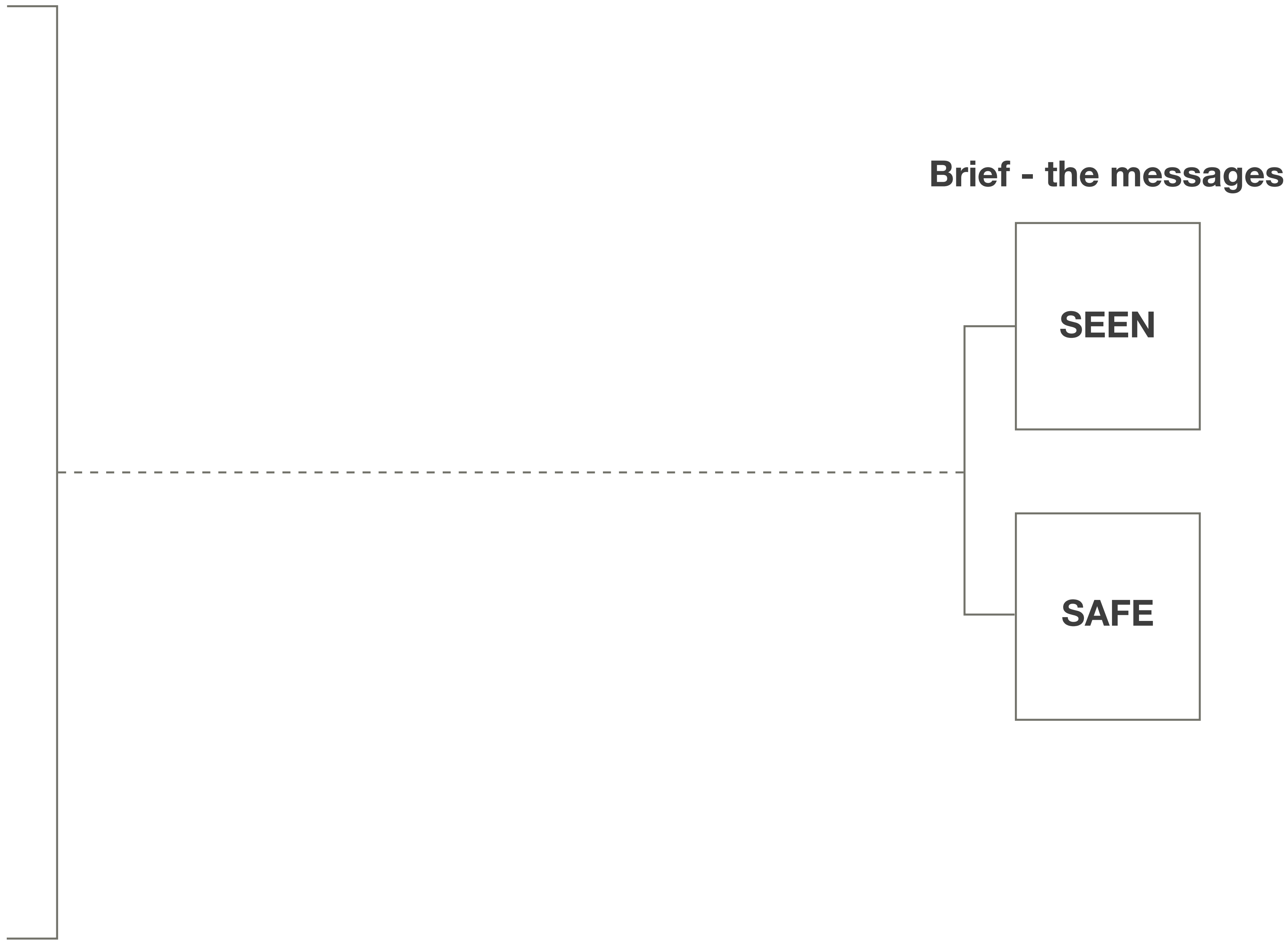
“Driver”
Adding a faux driver

Text

Traffic symbols
Conventional traffic language

Reflection
Depict the pedestrian on the vehicle

Facial expressions
Displays of emotions as a means of communication



Sound
For further development
Since it is a visual element that has been lost, I chose to go with a visual solution. Sound is also used at crossings, and is worth exploring further.

Other senses/solutions
Worth exploring at a later opportunity.

React

Horsey Horseless, 1899.

Drew Driverless, 2018.

“Driver”

Using a faux driver

One conclusion I drew from my journey, is that the AV is lacking the interaction that the driver provides. It is this interaction that I want to re-introduce, and it does not necessarily have to come from a faux driver. By only looking at the present, there is a chance of stumping a project in its development, which is why I want to look at other possibilites.

Conclusion - NO

- I am only interested in the driver interaction.

Button at crossing in Japan. Should you press or not?

Text

Not everyone can read

Regardless of language barriers, and level of literacy, the observer should still be able to instantaneously understand the message, and act accordingly.

Conclusion - NO

- Text is not universally understood - do not use text.

Not. The text says to "please wait".

Traffic symbols

Walking figure

Street signs can vary greatly depending on location. The geometrics seem to have no common factors beside their simplicity. But what they do seem to have in common is the human figure. It comes in variations of detail, shape and direction. But even so, they share the traits of being high in contrast, and having a stance identifiable as "walking".

Lines

Where signs have a greater variations, the road markings are fundamentally the same wherever you are. Long, broad lines that are parallel to the road are a global marking for crossings.

Green, the only "safe" colour

Supporting element, not the main due to colourblindness.

There lies much cultural history and meaning behind colours. In the west, one colour can have several meanings, that are the complete opposites from one another. For example, red can be recognized as the colour for love and passion, at the same time as it is connected to blood and used as a warning colour. ("The Meanings of Colors: Red". (n.d.).

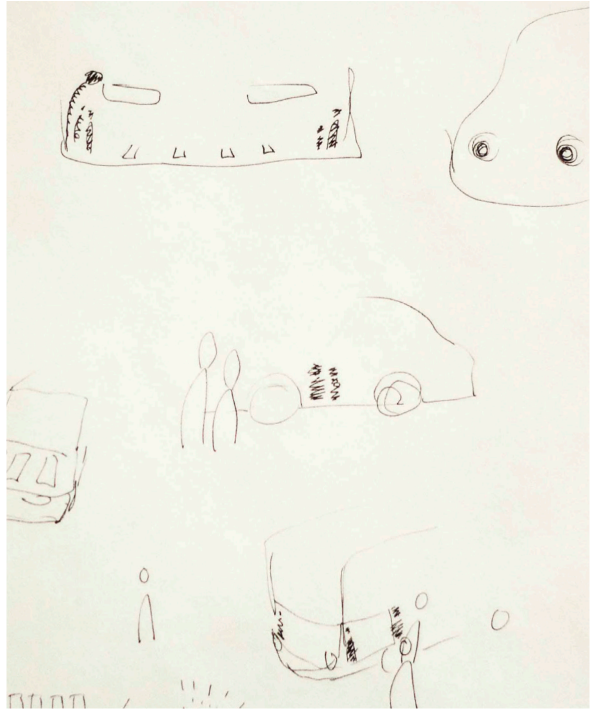
By looking at different countrie's safety and warning signals, especially those related to traffic, I found that both categories share many colours. However, I found only one colour that was exclusive to the safe category; green.

Whilst it is convenient to have a colour that is globally recognized as "safe", it is troublesome when parts of the population may have a hard time identifying it. Colour blindness can vary greatly between people. The most common type of colourblindness is deuteranomaly, a reduced sensitivity to green light. But even amongst people with deuteranopia, the degree of sensitivity differs. ("All about color-blindness". (n.d.).)

Conclusion - YES

- Conventional traffic signs are understood globaly.

Daniel Rozin, interactive mirror art. © University of Colorado Art Museum. Photo Jeff Wells 2010.



Reflection

Reflecting pedestrian silhouettes

An early idea was to use the concept of the artist Daniel Rozin's mirrors to reflect the pedestrians' silhouettes. With details removed, the reflections would be more reminiscent of mirrors than cameras. This would lessen the risk of invading on the pedestrians' privacy, and minimize the feeling of being monitored.

In practicality, it would be difficult to reflect the pedestrians with adequate visibility. The advantage of diminished details is also a disadvantage. The shape would not necessarily be recognized as a reflection, and an issue arises when there are several pedestrians. The reflection also requires a significantly sized area to give a proper read.

Conclusion - NO

- Reflections have a bad read due to distance, area of reflection, and in cases with multiple pedestrians.

“I’m your friend too, Bart”. Is he really? Mr. Priest, as played by actor Alan Tudyk, in Dirk Gently’s Holistic Detective Agency.

Facial expressions / Smile (mouth)

Different culture - different interpretation

Cultural differences can determine how a smile is perceived. A study has shown that Americans largely look to the speakers mouth when gauging emotion, whereas the Japanese look to the eyes. (Wenner, M. (May 10, 2007). “Americans and Japanese Read Faces Differently”. Live Science.).

My unwillingness do delve into the area with human expressions lied in the fact that I felt that this had already been done with Semcon’s smiling car. But as I showed this car to others I got the comment; “It looks as if it’s happy to run me over”. A smile can say many things, but eye-contact has one fundamental meaning; “I see you”. I came to the, maybe obvious, realization that people interpret facial expressions differently.

Conclusion - NO

- Smiling is interpreted differently by different cultures, depending on what area of the face is “smiling”.

Facial expressions / Eye-contact

“Gaze detection” - A primal ability to gauge when we are being watched.

We firstly look to a person’s body when gauging someone’s gaze. The direction of the head and body indicates whether that person is turned towards you or not. This can alert you to the direction of their gaze.

But how do we react when the body does not provide us with any cues? According to professor Colin Clifford, a psychologist at the University of Sydney’s Vision Center, we humans naturally assume that we are being watched. In a study led by Clifford, in settings where the test-subjects could not clearly see the eyes, they reported that were being watched.

Besides preparing for danger, Clifford suggests that this might be a preperation for interaction or conversation. Our gaze is often a social cue, indicating that a person is seeking to communicate with us.

(Enoch N. (April 12, 2013). “Think someone’s staring at you? You’re not paranoid... it’s ‘hard-wired’ into our brains”. Daily Mail UK. Retrieved October 19, 2018, from https://www.dailymail.co.uk)

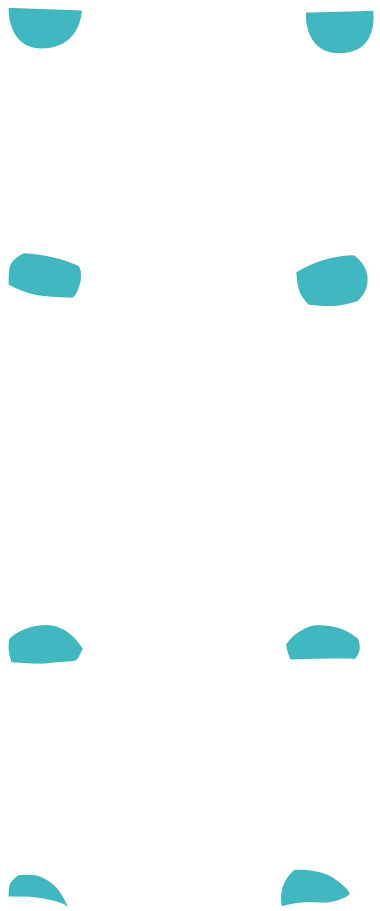
Conclusion - YES

- Hinting at eyes give the impression of being seen/watched

Photo by Erica Magugliani.
Sunglasses covering the eyes, body facing away, face directed slightly above and to the side of the camera. There is no definite way to determine where her gaze is directed.

Angry babies.

Happy babies.



Corresponding shape of visible iris.

Facial expressions / Smile (eyes)

Shape the iris - shape the mood

What sets our eyes appart from most animals, is the size of our iris (coloured area) in relation to our sclera (white area). This gives us the benefit of being able to see where a person is looking. Predetors benefits from their prey not being able to correctly interpret the direction of their gaze. However, for humans, being able to see where a person is looking, is a social advantage.

Besides the direction of our gaze, our facial expressions play a huge part of our emotional communication. Different muscles in the face are activated when portraying different emotions.

Many of these muscles are around the area surrounding the eyes. So when looking to a person's eyes, we can distinguish both the direction of the gaze, and the mood of the person.

I argue that due to the distinguishable relation between sclera and iris, it is the iris that ultimately conveys our mood. Covering up parts of the iris with surrounding muscle movement, changes the geometry of the otherwise perfect circle. Therefore the most minimalistic way of portraying emotions, would be to manipulate a circle with the appropriate changes. For example; in-wards slanting tops to portray angry eyebrows, the up-wards "bump" on the lower eyelid from the smiling muscle.

https://www.mnn.com/lifestyle/arts-culture/stories/why-can-we-sense-when-people-are-looking-us

Conclusion - YES

- Using simplie depictions of the iris is enough to convey different emotional states

Summary

"Driver"
Loss of driver - not the problem

It is not the loss of the person per se, but rather the loss of interaction which is the deciding factor.

Text
Not universal

Limited to literary individuals with knowledge of that language.

Traffic signals
High visibility & recognition

There are regional deviations, yet on a global scale, the founding principles are similar.

Reflection
Visibility problem

A reflection might not portray a distinguished form of the pedestrian. It is also problematic when there are multiple people waiting to cross.

Facial expressions
Ambiguous yet effective

Cultural differences play a part in this communication method. But by breaking down the components, a common trait may be found.

Colours
Can culturally have many different meanings. But in traffic their symbolism is globally similar.

Symbols
There are great variations in dimensions. But there are commonalities that can be applied in this context.

Smile (mouth)
The upwards curve of the corner of the lips indicate a smile. It is easy to fake a smile with our mouths.

Smile (eyes)
Muscles around the eyes move when we smile. A true smile can be discerned by a slight upwards curve of the lower eye-lid. This indicator is very hard to fake.

Eye-contact
Mutual recognition of the other's presence.

Green
Support from green, not dependence

Globally recognized as "safe". To cater to the colourblind, it is better to use the colour as a supporting element, rather than the main.

Walking figure
A common icon

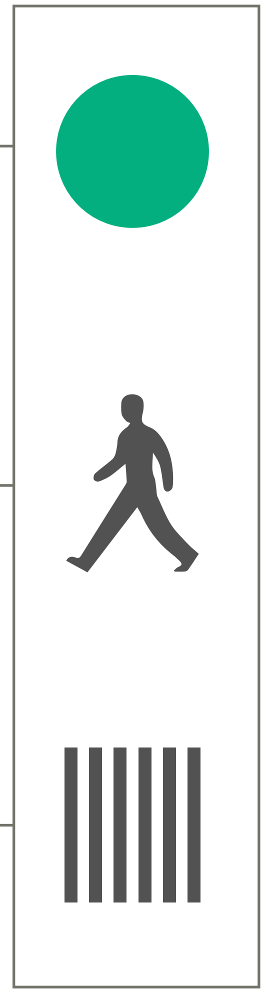
The shape comes with variations in direction, shape and detail. What the variations share is being high in contrast, having a clear walking stance.

Stripes
Globally used pattern

Where signs have a greater variations, the road markings are fundamentally the same wherever you are. Long, broad lines that are parallel to the road are a global marking for crossings.

Smiling eyes
By using the eyes, the pedestrian can get two confirmations at once: That they have been seen and that the vehicle is positive to their presence.

SAFE



SEEN

Stand-by

COMMUNICATION TOOLS /
DECISIONS

- Use smiling eyes for “seen”.
- Use traffic signals for “safe”.

Stand-by

ANALYSIS /

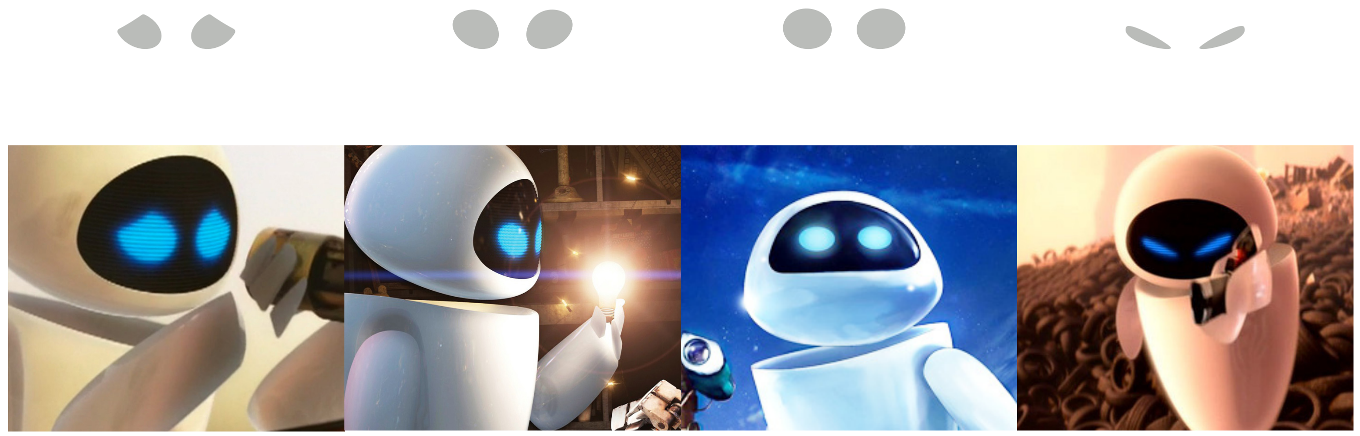
ANTHROPOMORPHISM

Attributing human traits, emotions, or intentions to non-human entities. Examples of anthropomorphism in and emotional display, conceptual cars, and a dip into the uncanny valley.

Two eyes and five words

A great example of simple, yet clear eye-design, is the animated character, Eve.

Wall-E is the protagonist of the Disney Pixar movie by the same name. He can say his name, and the name of his love-interest, Eve (although he can not properly pronounce it, and throughout the movie calls her Eva instead). That is the extent of his vocabulary. Eve posses a few more words, such as “directive” and a barely discernible “who are you” (ooaaiuu). They both communicate with gestures, intonations, and facial expressions. These facial expressions are conveyed with nothing but their “eyes”, since they possess no other facial features. Wall-E’s eyes are what appears to be two camera lenses, that are angled in different directions to express his emotions. Eve’s eyes are projected as circles from a screen, which allows her to shape her eyes with greater freedom. However, she still has to portray every emotion with only geometrical variations of a circle.



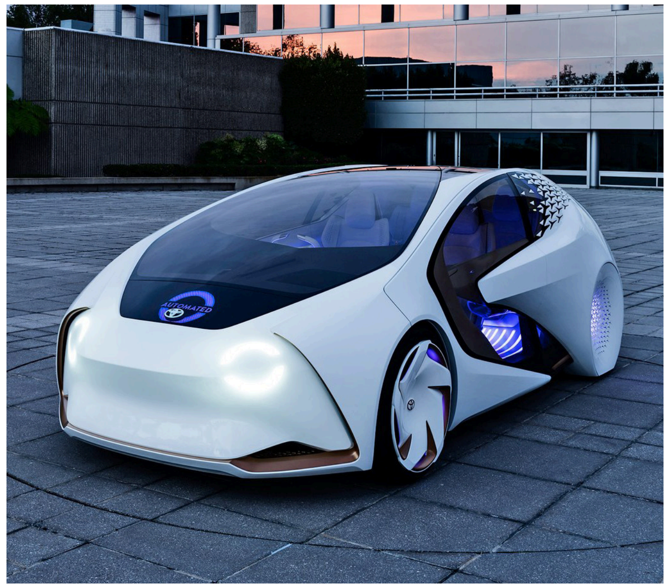
Eve, Wall-e movie, Disney Pixar 2008.

Cars and anthropomorphism

Attributing human traits to non-human entities

There is a fine balance between characteristic and caricature. In the same way that visualizing a substitute “driver” is unsuitable, so is creating an anthropomorphic car. As mentioned earlier, a visualized entity with facial expressions can not clearly convey the needed messages. There are, however, other benefits of giving the vehicle some human traits. Toyota’s Concept-i, Yui, explores the possibility of a car with a personality . Using AI-programming to learn more about its user, the car maps the user’s habits, mood and favorite places. It can act as a friend and recommend the driver on an action based on these learned traits. This is a part of a trend in “humanizing” robots. From Amazon’s Alexia, to SoftBank Robotic’s Pepper, there is something to be gained by manufacturing personality. Whether it be for raised product interaction or brand fidelity, emotional design is gaining momentum.

Lightning McQueen, Disney Pixar.



Toyota’s 2017 concept car, Concept-i.

Technical solution

From headlights to eyelights

Autonomous vehicles have no need to light up the road ahead of them. Headlights serve two purposes - to light up the road for the driver, and to signal that the vehicle is turned on and active. Signalling to its surroundings that it is in operation, is still a necessary feature. Other drivers, cyclists and pedestrians need to be informed of the vehicle's status. But without the driver, there is no actual need to light up the road. The vehicle navigates with GPS, cameras, sensors and lasers. Whether it is dark or bright outside, makes no difference to the car.

Screens on the front of the vehicle would be able to display the messages from my brief. The messages are time sensitive, and an adaptive canvas could deliver them at the right time.

Toyota's 2017 concept car, Concept-i, and the 2015 Toyota Camry Xle. Concept-i's headlights are hidden behind the paint, and can wink as their owner approaches.

\+

Familiarity

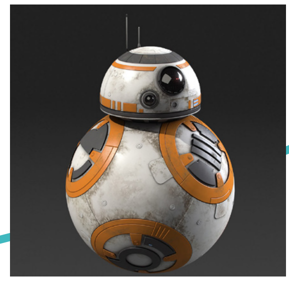
Uncanny Valley

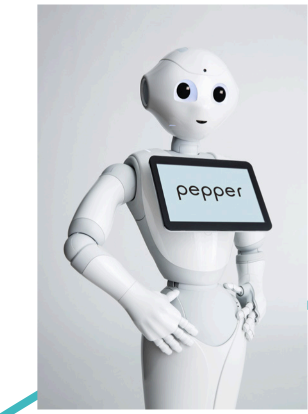
The uncomfortable stage of anthropomorphism before realism.

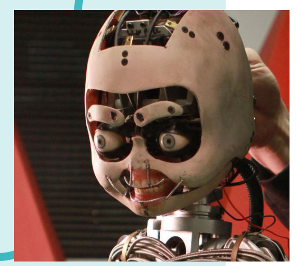
In 1970, roboticist Masahiro Mori saw an increase in positive response towards robots, the more human like they were. Up to a certain point, when the robots looked almost, but not quite, like humans. Instead, the response turned to unease and discomfort. Past this point, when the robots became very close to human, they were again received positively.

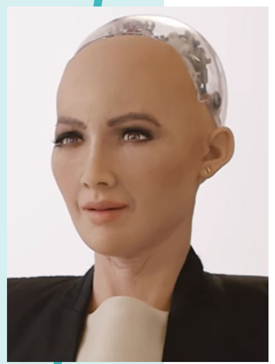
This phenomenon has been dubbed the Uncanny Valley, and has been in a number of studies since. The exact boundaries for the Uncanny Valley is still discussed, since there are a number of variables that need to be taken into consideration. The observer's age, sex, nationality; if the robot/animation/other is moving or still, if it is displaying emotion, if it appears to have a consciousness, etc.

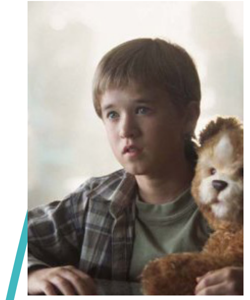
In a 2013 study (https://doi.org/10.1016/j.chb.2013.01.008) virtual characters were animated to react to different loud noises. Typical psychopathic markers are the lack of emotional response around the eye. The characters were therefore animated to react mainly with the lower half of the face. Characters that showed a lack of startled response to a scream, were reported as the most uncanny. Characters animated with psychopathic traits were also pointed out as eliciting uncanniness. This would suggest a possible connection between the uncanny and our subconscious recognition of psychopathy.











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Human likeness

Left to right: Industrial robot. BB-8, Star Wars. PaPeRo Petit, NEC. Pepper, Softbank Robotics. Sonny, movie I, Robot (2004). Animatronics, music video of Daft Punk's "Technologic" (2005). Sophia, Hanson Robotics. Haley Joel Osment as "David", movie A.I, Artificiall Intelligence (2001).

Stand-by

ANTROPOMORPHISM /
DECISIONS

- Use “eyelights” instead of headlights.
- Make the eyes expressive and not too human.

ANALYSIS /

CHAPTER SUMMARY

Journey

AV should imitate driver mannerisms by communicating that it:

1. Sees the pedestrian

1a. Reacts to the pedestrian

2. Observes the pedestrian

Communication tools

- Smiling eyes for "seen".

- Traffic signals for "safe".

Antropomorphism

- Use "eyelights" instead of headlights.

- Not too human eyelights.

116_SYNTHESIS /

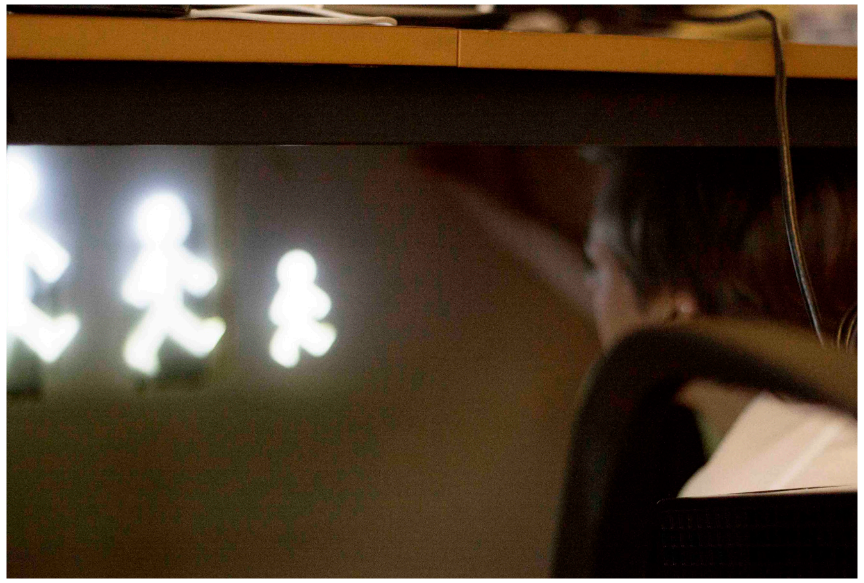
A deep-dive into the journey and its stages. Using the decisions made in the previous chapter, the stages are given their respective interaction. The form is developed through the process of animating the interaction, and can be seen in the Result chapter.

Stand-by

SYNTHESIS /

SKETCH PHASE

Feeling out the size with proper light gave a clue as to the shape needed. What size do the figure need for clear visibility from the crossing?



Testing the light with different materials

At this point I came to the conclusion that the core of my project lies in the graphic message, and the hardware is something that can be developed with a car manufacturer. This would allow the car brand to adapt the graphics after their model, and the fine tuning in, for example, light-intensity, can be done in combination with the car testing.

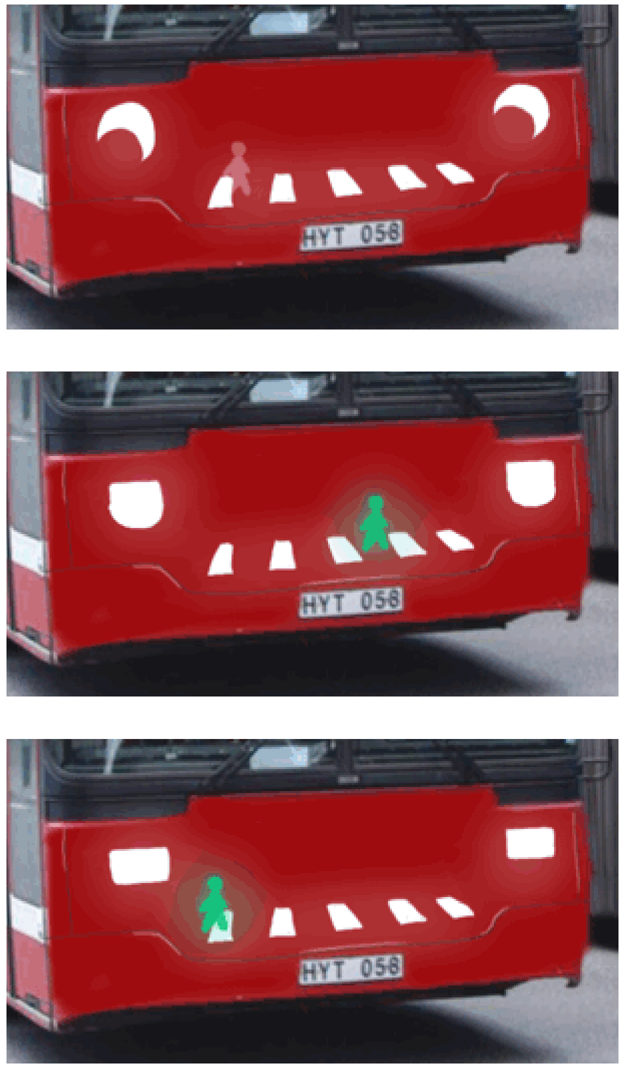
Checking colour and shape contrast

These rough shapes were slightly hard to read from a distance. This made me reflect over the familiarity we have with the walking figures we have today. There is no need to re-invent the wheel, and I decided that using existing walking figures ties back to my earlier conclusions; that the symbols should be something that is instantaneously recognized.

Early conceptual animations

Too human

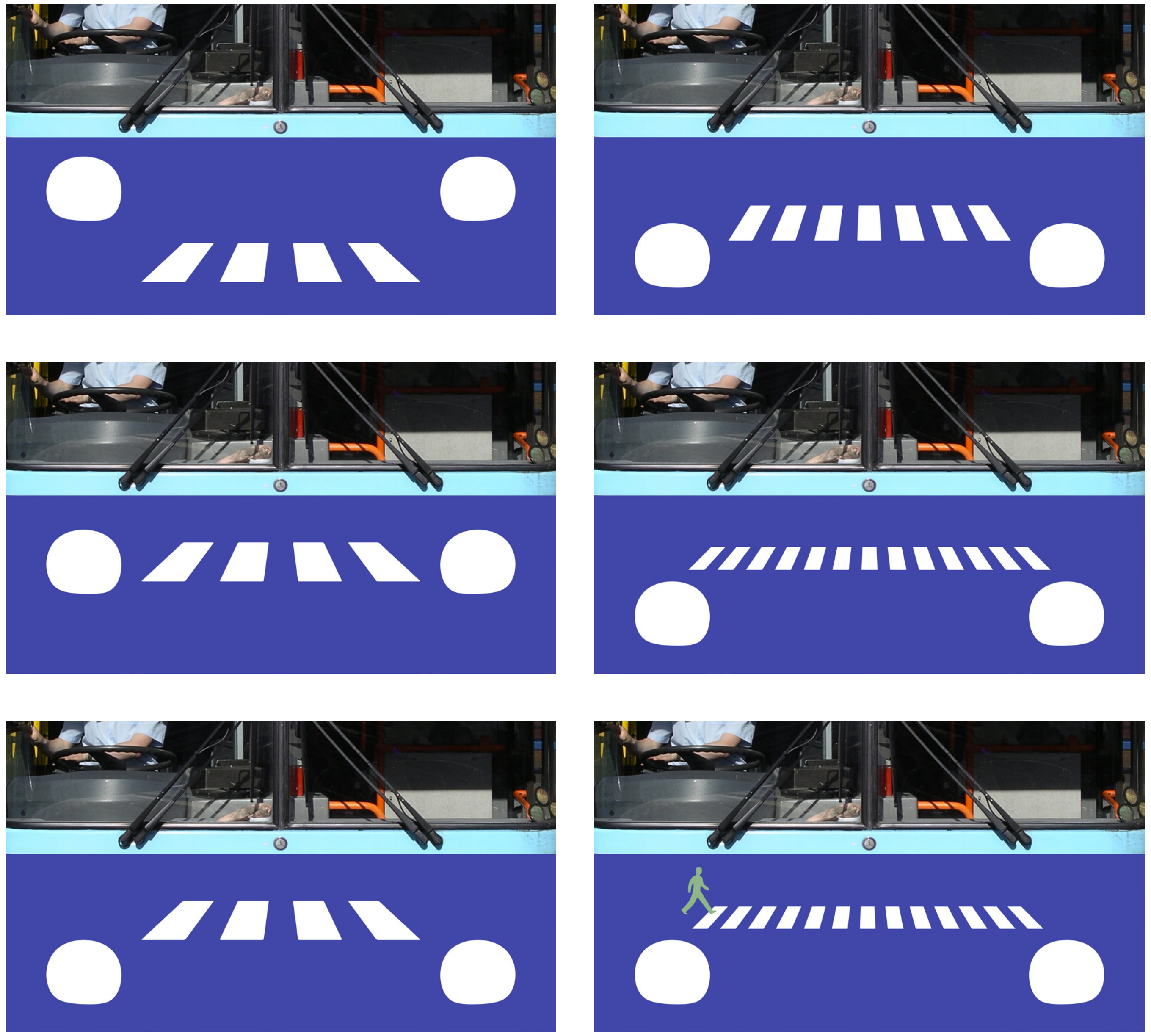
The addition of pupils made the bus too human like. This ties back to my conclusion that I want to avoid realism, and I chose to forego pupils.



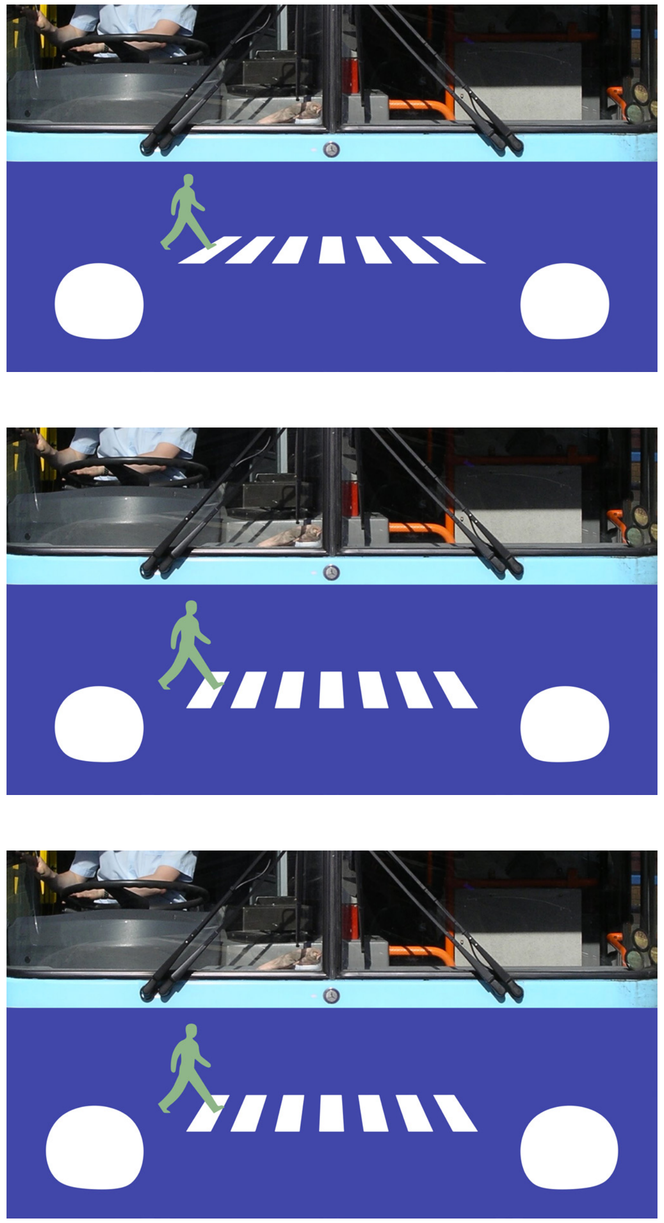
Simple GIFs for proof of concept

At this point I was feeling out how the concept would be interpreted by people. An inital round of user testing gave a positive response, and I continued with developing the form of the eyelights, stripes and figure.

Proportions and positioning



Positioning the eyelights and stripes so that they do not unintentionally get interpreted as eyes and mouth.



Giving the figure a higher hierarchy so as to have it in focus.

FORM STUDY

Headlights

A form reminiscent of classical headlights. Soft edges to give it a kind expression.

Blinking awake

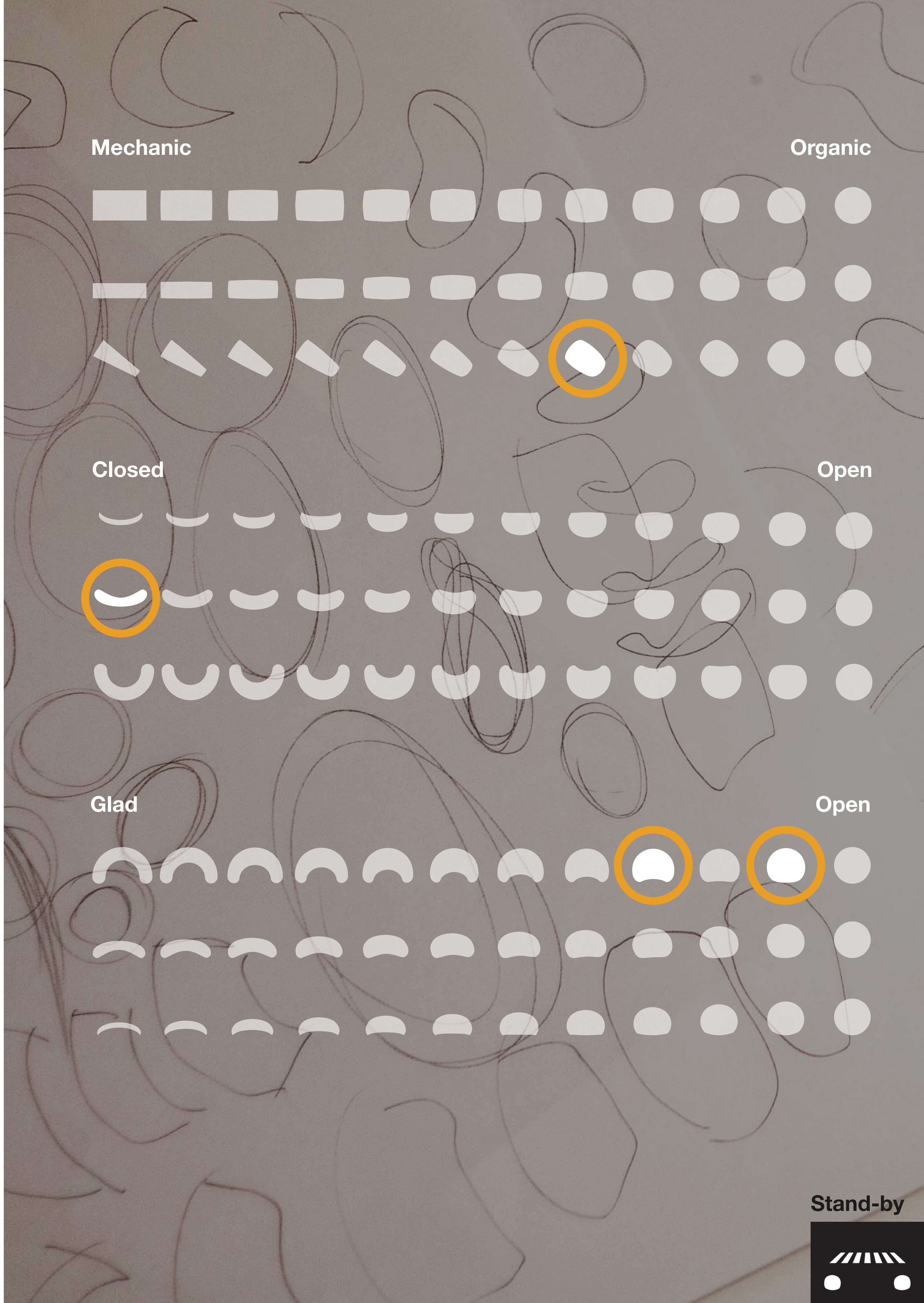
The eyelights go from being a car to blinking <u>once</u>, as if with eyelids.

Smiling

Curved upwards to mimic the “smiling muscle” under our eyes.

Watchful

The eyelights are “wide open” in their expression, indicating that they are paying attention.



SYNTHESIS /

INTERACTION MAPPING

Translating driver interaction at action stages

The stages of Drive, Detect, Act, Stand-by, are the key points which the interaction will revolve around. The decisions from previous pages will be implementet at one or several of the stages.

Decisions to implement

Journey

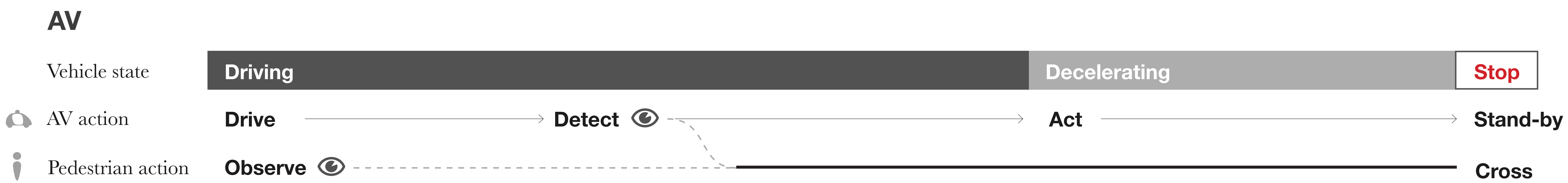
AV should imitate driver mannerisms by communicating that it:
- Sees the pedestrian
- Reacts to the pedestrian
- Observes the pedestrian

Communication tools

- Smiling eyes for “seen”.
- Traffic signals for “safe”.

Antropomorphism

- Use “eyelights” instead of headlights.
- Not too human eyelights.



Stand-by

Drive → **Detect** → **Act** → **Stand-by**

“I am car, therefore I drive”

During the drive stage, contact between driver and pedestrian has not yet been established. No eye-contact is involved at this stage, so my design should have the shape of headlights.

Form

Decisions to implement

- Sees the pedestrian
- Reacts to the pedestrian
- Observes the pedestrian

- Smiling eyes for “seen”.
- Traffic signals for “safe”.

- Use “eyelights” instead of headlights.
- Not too human eyelights.

Stand-by

Drive → **Detect** → **Act** → **Stand-by**

“Oh, someone’s here!”

Waking up, becoming alive.

In the detect stage, I want the eyelights to “wake up”, and have more human traits to show that it is changing into a “cognitive entity”. It should display that it is reacting to the crossing or pedestrian

Interaction

1. Lines appear
2. The eyelights react to this; blinks awake.

Decisions to implement

- Sees the pedestrian
- Reacts to the pedestrian
- Observes the pedestrian

- Smiling eyes for “seen”.
- Traffic signals for “safe”.

✓ - Use “eyelights” instead of headlights.

✓ - Not too human eyelights.

Drive → Detect → Act → Stand-by

Act

"I've got this, I'm slowing down"

Friendly expression to build trust.

The walking figure appears first; indicating what the eyelights are reacting to. This extra feedback allows the vehicle to display a proxy of the reaction delay between Detect and Act. The eyelights respond with smiling, and the vehicle is slowing down.

Interaction

Detect:

1. Lines appear.
2. The eyelights react to this; blinks awake.

Act:

3. Walking figure appears
4. The eyelights react to this; smiles.

Traffic signs

Detect:

Act:

Headlights

Drive:

Detect:

Act:

Decisions to implement

Detect:

- Use "eyelights" instead of headlights.
- Not too human eyelights.

Act:

✓ - Sees the pedestrian
✓ - Reacts to the pedestrian
- Observes the pedestrian
✓ - Smiling eyes for "seen".
- Traffic signals for "safe".

(A green walking figure, with a lot of blue, to help the colourblind, and enhance the message of safe.)

Stand-by

Drive → Detect → Act → Stand-by

Stand-by

"Go ahead, you can cross"

Open. Both friendly and watchfull.

Eyelights that are observant. Now the pedestrian should know that it is ok to cross, and I want the eyelights to be passive. The walking figure walks across the lines, to indicate that it is ok to cross.

Interaction

Detect:
1. Lines appear.
2. The eyelights react to this; blinks awake.

Act:
3. Walking figure appears.
4. The eyelights react to this; smiles.

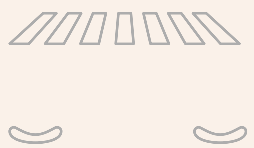
Stand-by:
5. The eyelights are open and observing
6. Walking figure blinks across lines

Traffic signs

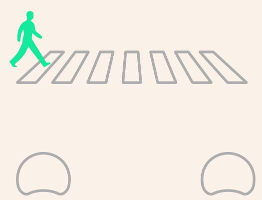
Headlights

Drive:

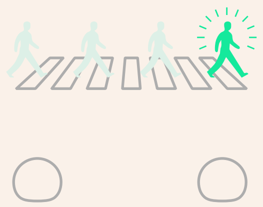
Detect:



Act:



Stand-by:



Decisions to implement

Detect:
- Use "eyelights" instead of headlights.
- Not too human eyelights.

Act:
- Sees the pedestrian.
- Reacts to the pedestrian.
- Smiling eyes for "seen".

Stand-by:
- ✓ - Observes the pedestrian
- ✓ - Traffic signals for "safe".

(Right-side traffic, figure walking to the right.)

Stand-by

Stages complete - what happens in-between?

The eyelights are meant to emulate the driver and have a life-like response. This requires them to be expressive and have movement.

	Drive	Detect	Act	Stand-by
Interaction		1. Lines appear. 2. The eyelights react to this; blinks awake.	3. Walking figure appears. 4. The eyelights react to this; smiles.	5. The eyelights are open and observing. 6. Walking figure blinks across lines.
Traffic signs				
Headlights				
Decisions to implement		- Use "eyelights" instead of headlights. - Not too human eyelights.	- Sees the pedestrian. - Reacts to the pedestrian. - Smiling eyes for "seen".	- Observes the pedestrian. - Traffic signals for "safe".

Stand-by

SYNTHESIS /

ANIMATION

The 12 Principles of Animation

How to make a 2D character adhere to the laws of physics, have appeal, and display emotions.

For the eyelights, I used the twelve principles of animition, as described by Disney animators Ollie Johnston and Frank Thomas, in their 1981 book The Illusion of Life: Disney Animation.

1 **Squash and Stretch**
Gives weight and flexibilty. Like the muscles of a face or the bouncing of a ball.

2 **Anticipation**
Prepares viewer for action. Ex. bending knees before a jump.

3 **Staging**
Directs viewer’s gaze to what is important.

4 **Straight Ahead Action and Pose to Pose**
Techniques for drawing next frame.

5 **Follow Through and Overlapping Action**
Secondary part of object that moves at different speed. Ex. hair.

6 **Slow In and Slow Out**
Real objects have slower speed at the beginning and end of an action.

7 **Arc**
Natural actions tend to happen in arcs.

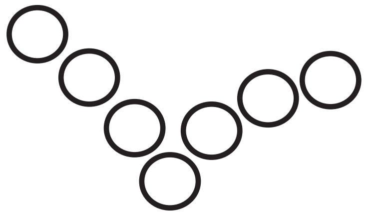
8 **Secondary Action**
Gives more life by complementing main action. Ex. swinging arms when walking.

9 **Timing**
The speed at which something happens. Can communicate state of mind, weight of objects, etc.

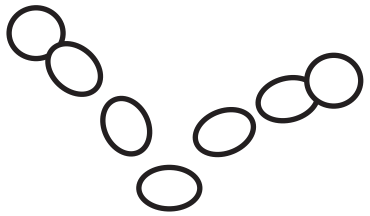
10 **Exaggeration**
Gives the impression of something “more than life”. Bigger movements, exaggerated characteristics, etc.

11 **Solid drawing**
Drawing should look 3D in 2D.

12 **Appeal**
The character should be interesting to the viewer.



Ball in arc.



Ball in arc with squash and stretch.

A frame of Tom from Tom and Jerry, MGM cartoon studios. The frame does not depict what we would see in reality, but with other frames in quick succession, will give the impression of motion and life.

Stand-by

The stages are my Keys

Frames and pose to pose animation

Animation is a series of pictures displayed in fast succession to give the illusion of movement. One picture is called a frame, and 24 frames per second is a standard for creating animations with smooth movement.

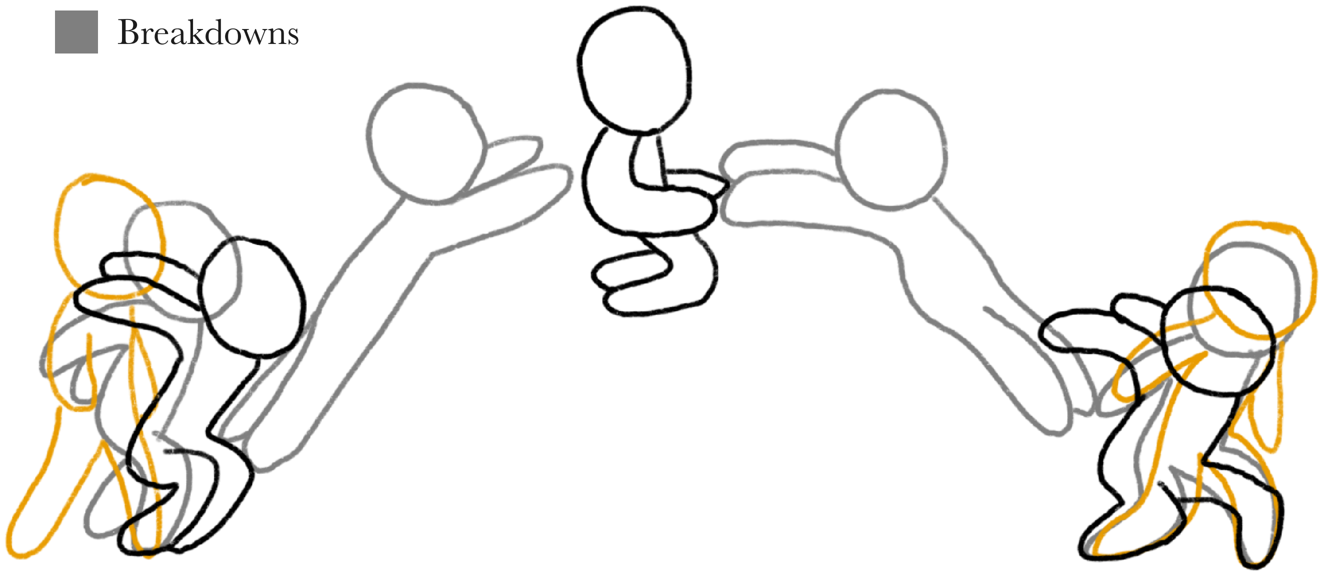
Pose to pose animation is when the object has a starting pose, a goal pose, and the animator draws the poses in between. The start pose and goal pose are called “keys”, and the stages defined in the previous chapters, can be used as such.

The “extremes” and “breakdowns” are what takes the object between the keys. The extremes are often drawn first to provide a path to the most extreme movement the object can make. The breakdowns then connect the extremes with the keys.

Keys

Extremes

Breakdowns



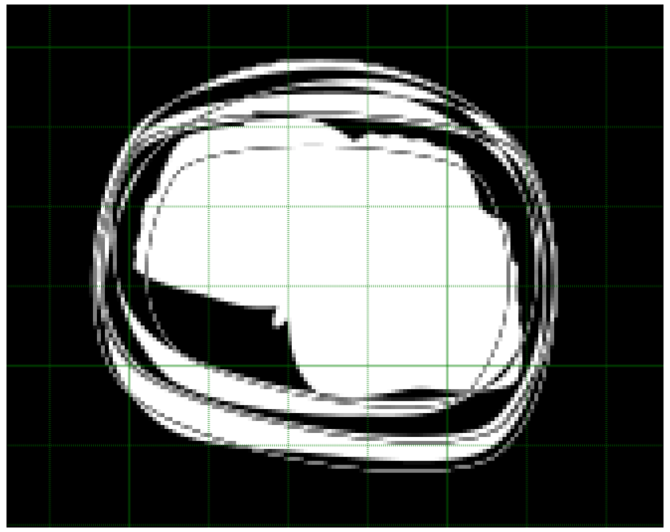
Form changes due to the nature of animation

Animation and still pictures have different requirements

For the animation I used After Effects, which had the functions I needed to give the eyelights life.

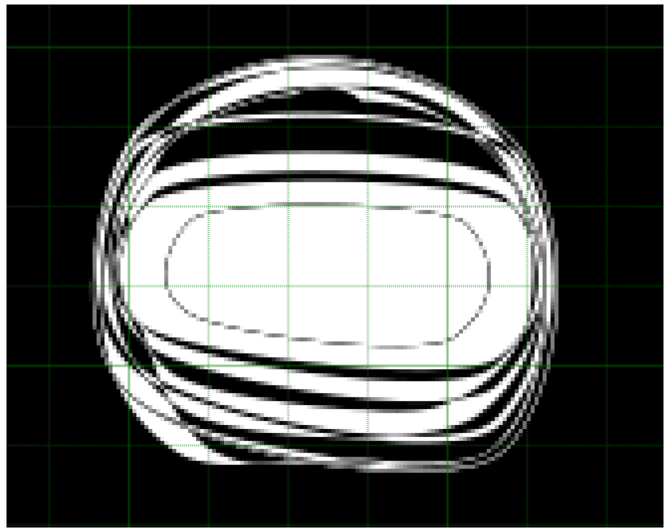
Adapting the keys (stages) to movement that would represent the desired emotions required detailed adjustments. Through the process of animation, the original form of the keys took on different shapes.

1 sec



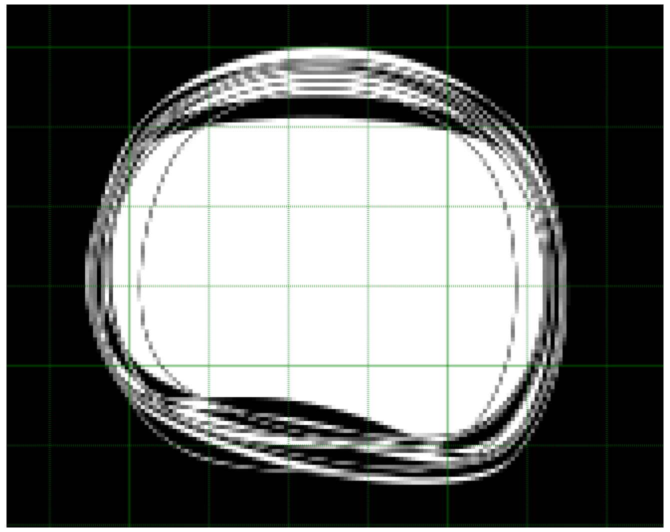
13 iterations

1.25 sec



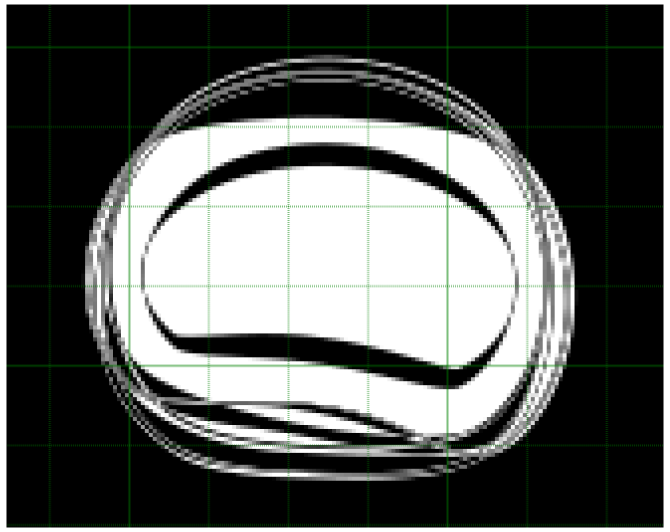
11 iterations

1.5 sec



16 iterations

3 sec



10 iterations

Examples of iterations on four different frames. The pictures show overlapping iterations on a frame.

144_RESULT /

The resulting product, what needs to be considered in the future, and how can it be improved.

Hypothesis
SAFE + SEEN = CROSS

Stand-by

Result / Scene

Drive

Detect

Act

Stand-by

"I am car, therefore I drive"

During the drive stage, contact between driver and pedestrian has not yet been established. No eye-contact is involved at this stage, so my design should have the shape of headlights.

"Oh, someone's here!"

Waking up, becoming alive.

In the detect stage, I want the eyelights to "wake up", and have more human traits to show that it is changing into a "cognitive entity". It should display that it is reacting to the crossing or pedestrian

1. Lines appear
2. The eyelights react to this; blinks awake.

"I've got this, I'm slowing down"

Friendly expression to build trust.

The walking figure appears first; indicating what the eyelights are reacting to. This extra feedback allows the vehicle to display a proxy of the reaction delay between Detect and Act. The eyelights respond with smiling, and the vehicle is slowing down.

3. Walking figure appears
4. The eyelights react to this; smiles.

"Go ahead, you can cross"

Open. Both friendly and watchfull.

Eyelights that are observant. Now the pedestrian should know that it is ok to cross, and I want the eyelights to be passive. The walking figure walks across the lines, to indicate that it is ok to cross.

5. The eyelights are open and observing
6. Walking figure blinks across lines

Stand-by

THE SYMBOLS CONVEY SAFE, THE EYELIGHTS CONVEY SEEN

The appearance of the traffic symbols are the vehicle indicating two things; first, "crossing detected" and later, "pedestrian, cross now". The green walking figure, blinking across the lines, in combination with a stand-still vehicle, should convey that it is safe for the pedestrian to cross.

To reassure the pedestrians that their presence have been detected, I added the eyelights to visualize the "thinking process" of the vehicle, portraying the actions of a driver. The eyelights give pedestrians a subconcious cue that they are seen, thereby fulfilling the second message in my brief.

Vehicle state	Driving		Decelerating	Stop
AV action	Drive	Detect	Act	Stand-by
Pedestrian action	Observe			Cross
Interaction		1. Lines appear. 2. The eyelights react to this; blinks awake.	3. Walking figure appears. 4. The eyelights react to this; smiles.	5. The eyelights are open and observing. 6. Walking figure blinks across lines.
Decisions		- Use "eyelights" instead of headlights. - Not too human eyelights.	- Sees the pedestrian. - Reacts to the pedestrian. - Smiling eyes for "seen".	- Observes the pedestrian. - Traffic signals for "safe".

Stand-by

Flip to see animation

Simplified version

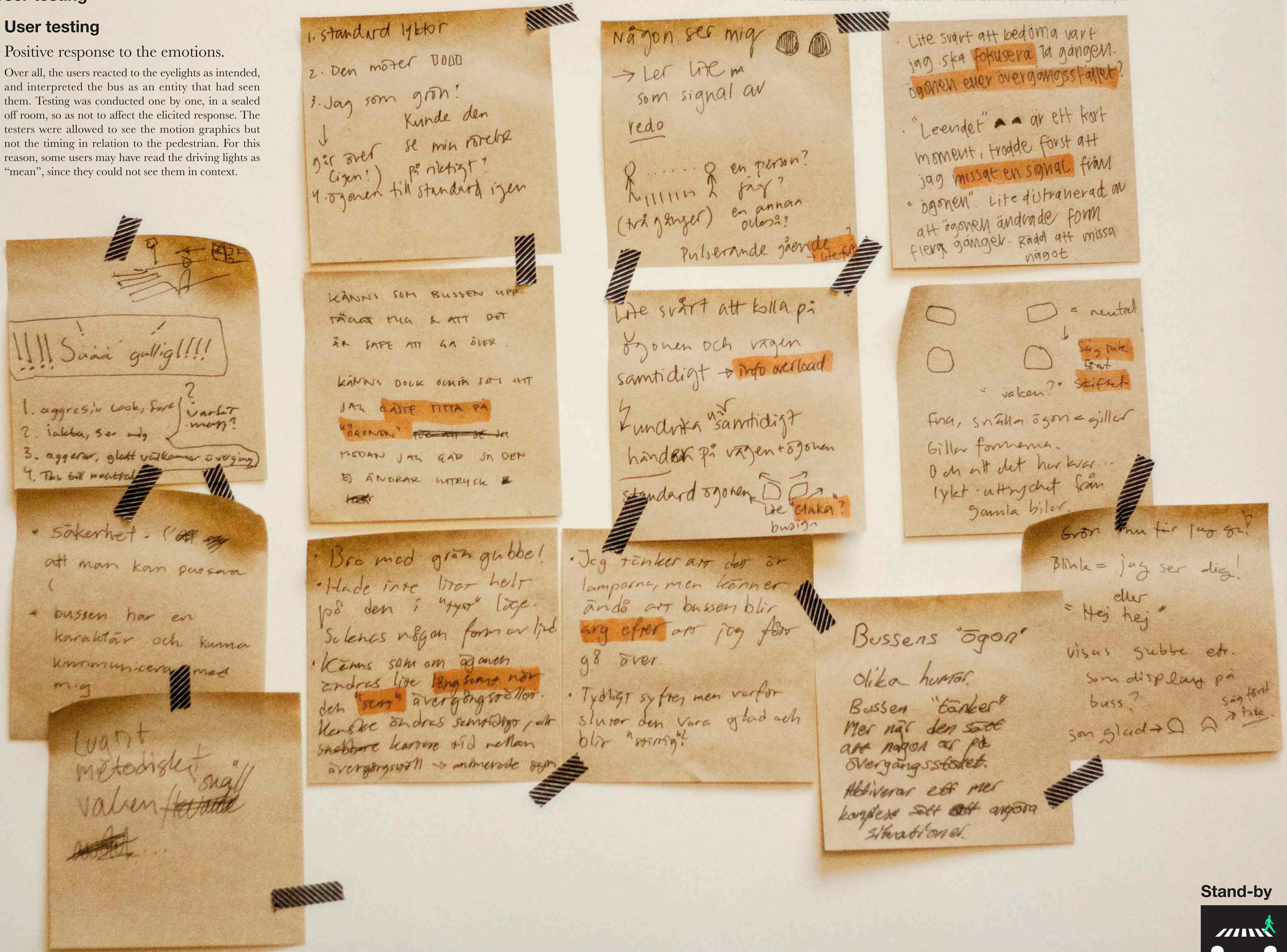
The animation has over 300 frames in the stages Detect, Act, and Stand-by. To fit the animation on 75 pages, I've removed every other frame (going from 24 fps, to 12 fps) and the "pauses" between stages. These pauses would set the tempo in a real setting, but as a flip animation, would not contribute to the experience.

Stand-by

User testing

Positive response to the emotions.

Over all, the users reacted to the eyelights as intended, and interpreted the bus as an entity that had seen them. Testing was conducted one by one, in a sealed off room, so as not to affect the elicited response. The testers were allowed to see the motion graphics but not the timing in relation to the pedestrian. For this reason, some users may have read the driving lights as “mean”, since they could not see them in context.



Stand-by

Reflection

Initially I had the impression that trust in the technology was the main issue that I was facing. And whilst this is a problem to overcome, it is not the main hindrance to autonomous vehicles being adapted into our society. I gained valuable insights from the interviews, and those are what have allowed this project to develop as it has.

Finding a problem

Exempts from the book Autophobia, has been incredibly helpful in this project. It recounts society's reaction to cars in their early days, with bans and restrictions that we find comical today. The raw animosity towards motorists was surprising to read about, but given the circumstances, I am not completely without sympathy. It amused me greatly to learn that early cars at times were called horseless carriages - echoing how we today refer to driverless car(riages). It was interesting to learn that many of the hurdles we are facing now, society has already overcome once, more than a century ago. Interesting, and oddly comforting, that we today share the same fears and worries that previous generations had. If we could overcome them once, we can do it again.

With this history in mind, I searched for how the public reacts to driverless cars, but could not seem to find a consistent source. This is what the experiment in Kista is doing at the moment, studying the public's reaction and how the technology is received. I contacted the leading researcher at KTH, but was unfortunately informed that they would not release their study until after the project's end. Even if I could not partake in their study I did a field trip of my own to ride the buses. I did not get a chance to interview other passengers, but the host provided me with some interesting facts about the general reception.

I still could not pinpoint a concrete problem that needed solving. I was stuck in this mindset that there was a general mistrust, but had no actual proof that this was a relevant issue. Especially since after Anna Haupt put my perception on end with her impression that it is the industry that is resisting development, and the public is clamoring for it. This was the complete opposite of my theory and I was at a lost as to how to continue.

Claes Herlitz's recounting of the effect of the lost eye-contact got me back to Semcon's smiling car. It was a confirmation that this is indeed an area that needs development, and it is relevant for instilling a feeling of safety. My unwillingness do delve into this lied in the fact that I felt that this had already been solved. I did not want to steal an idea, and I was charmed by the concept of retaining the humanity in the feedback. But as I showed this car to others I got the comment; "It looks as if it's happy to run me over". A smile can say many things, but eye-contact has one fundamental meaning; "I see you". I came to the, maybe obvious, realization that people interpret facial expressions differently.

Discarding ideas

I really enjoyed the idea of reflecting the pedestrian's silhouette back to them. This would give them a direct confirmation that they have been noticed. Although this was a charming idea that I had a hard time letting go of, the visibility issue was what ruled it out.

For the technical solution, I had the idea of using thermochromatic paint on the vehicle. This proved to have even more issues. I had hoped that I could come up with an analogue way to display my message. But I could only figure out technical solutions to solve the paint's problems.
Using human-like eyes for the headlights was never an option. But for the sake of not excluding any idea from the start, I tried it out in my early iterations. But the bus got an instant cartoonish look and was slightly uncanny.

Demarcations

There are many factors that build a vehicle's overall atmosphere. Most importantly, the actual physical parts of the car. As much as I would have wanted to make a bus front, I could not justify making one. The goal of my project was to elicit certain emotions at a specific time. And these I felt I could produce with only motion design. Matching the front with the graphics could open up new opportunities and solutions. But considering the scope of the project, I limited the work to only the graphics.

I also chose to only work with this one scenario with pedestrians. This was because of the time limitations, but also because we do not yet know what other problems, or opportunities, will arise. Buses could use eye-tracking to adapt it's visual and auditive message, depending on whether the pedestrian is attentive or not. A bus could warn the pedestrian of an approaching car that is about to speed past it. The bus could help those with visual impairment and give them exact instructions on how to cross.

The signals I have chosen fit into my brief of providing a visual feedback for the pedestrian. The reason for focusing on the visual feedback is on account of the loss of it in the first place. But there is no reason to only limit the vehicle's communication methods to our sight. Given that there are people with impaired vision, this solution does not cater to them in the least. Work needs to be done with auditive signals as well, which is a whole other area of research.

The design I have done is meant for the transition period. This means that traffic is dominated by human drivers, the roads have not been adapted to autonomous driving, and people are not used to driverless vehicles. This range of emotions displayed by the vehicle may prove to be redundant in the future. As people start to take the safety of the vehicles for granted, the need to confirm its intent will reduce.

Difficult emotions

Due to literate barriers, I do not want to use text to ensure that it is safe to cross. I am relying on established icons to convey the main message. On the other hand, it is not certain that the eye-movements will be interpreted by everyone as I have intended. User testing so far has given positive results, but the testing has been limited to other design students. Individuals on the autism spectrum can have difficulties with social interaction and non-verbal communication. And the eye-lights are relying on the pedestrians being able to pick up on these emotional cues.

One way to work around this design flaw is to exclude emotions entirely, through visual and auditory cues independent of emotion. But considering that the eyelights merely take on a supporting role, they still serve their purpose for those that can read them. Same applies for my choice of the colour green to convey 'safe'. People with colourblindness might struggle to identifying the colour. But in combination with the other signals, the green serves as a supporting indicator for those who can interpret it.

The industry

Design work is about mediating between all of the actors involved. But as of now, the prototype motion design has only been tested in a controlled setting with "users". My solution is strictly targeted to the pedestrian's need, leaving the manufacturers out of the process. I have received help from people within the industry, but this has largely been to identify a need and to learn about the current situation. I have no perception of how my idea would be received. Car companies have built an identity around the form and unique traits of their vehicles. Painstaking work is put into rejuvenating a trademarked detail, whilst still keeping true to its original form. Headlights fall under this category of trademark traits. Would the companies even consider this radical shift? Is the need of the pedestrians important enough to tackle? What new kinds of issues will the hardware bring about? These are some factors which may prove to be fatal to the concept.

There is still a lot of work to be done in the area of outer UI. I believe that what the vehicles communicate outwards will have an even bigger relevance than it does today. Not only with the actual signals, but also with the overall form of the vehicle. We know what cars are, and more importantly, how dangerous they are. Their speed, weight, and size make them deadly, and this is something that we may associate them with. Autonomous vehicles' strength lies in their safety, and to convey this, they need all the support they can get. The support from safe semiotic aesthetics, and communicative inner and outer interfaces.

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