THE FUTURE PEDESTRIAN AMONG SELF-DRIVING CARS

Alicja Halbryt

MA Service Experience Design and Innovation, LCC, 2019

Acknowledgements

This Master's dissertation is a result of genuine fascination with the futures and design. I would like to express my great gratitude to the kindest people who helped me achieve my goals and follow my passion. I am grateful to my supervisor Hena for her positivity and help, and the course leader Silvia for constant support and care over her students. I owe many thanks to MA SEDI tutors – Cordula, Phillippa, Veron, Paola, Lara and Allison for showing us the many faces of service design. I would also like to thank my mentor Peter who supported my exploration of artificial intelligence and provided with valuable insights throughout the project development. It was an honour to speak to the many design and technology experts, whose opinions enriched this report.

The journey through service design was made much more enjoyable thanks to my classmates and closest friends – Yoora and Pierre. I am very grateful to my parents and brother for their never-ending support and to Vinit for listening to my thought process and being there for me till the very end.

Abstract

Pedestrians – people who walk rather than travel in a vehicle – are inherent and the most vulnerable part of the traffic. Autonomous vehicles, the technology believed to be the future of transportation, is being developed to significantly increase people's safety and comfort on the road. However, technologies as complex as driverless cars usually hide a number of issues related to ethics and feasibility, which make some experts doubtful about the technological innovation and casual people fearful about their safety or freedom. This Master's dissertation explores the future of pedestrians living among self-driving cars and suggests a way to maintain their safety. It tries to link both service design and speculative design approaches to create a convincing future service scenario. The developed service concept is a new operating system feature – pedestrian mode – which enables connection between personal devices, autonomous vehicles, and pedestrian crossings. It increases pedestrian visibility to maximum, helps to smoothen the traffic flow and makes pedestrian behaviours predictable. This report aims to provoke discussion and thoughts about preferable futures for pedestrians in the age of driverless vehicles.

Table of contents

Introduction

Infrastructure blocks people's natural behaviours;
cities are made for cars.

~ Humanising Autonomy

How many times have you crossed the street today?
Did you look at your phone while crossing?
Did you make eye contact with the drivers to ensure that they see you?

Street-crossing has become a typical point of the day which no one really pays attention to. It is a necessary but quite an easy task, especially if done with respect to the traffic rules. In the future, it will very likely change, and it is not clear in what way. The future is believed to be autonomous – self-driving cars on the streets, blooming of the ride-sharing economy, no car ownership, less traffic. Autonomous car manufacturers compete every day to deliver a better version of a driverless vehicle, with test cars already on the streets.

It is only when investigating the matter further that the negative nuances come into play and make the future of transportation look only somewhat promising. Operations of the very specific piece of technology – autonomous vehicles – are full of uncertainties, especially from the pedestrian point of view. Self-driving cars are an example of an artificial intelligence system which is prone to algorithmic errors and lacks the human intuition – so often crucial on the road. What is more, people's excitement about not having to sit behind the wheel in the future is often mixed with a sense of danger and fear for life. Humans are afraid of what they do not understand, which is exactly the case – people do not understand the cars and the cars do not understand them.

This project attempts to dive deep into the future of London streets and suggest a way of street-crossing around self-driving cars. It seeks to develop a concept for a future service which would increase pedestrian safety, reduce their fears and prepare them for interactions with self-driving cars. As this dissertation is in fact a speculative design scenario, rather than proposing a highly feasible solution for current times, its primary aim is to provoke thoughts and discussions over the question 'is this a future we want?'.

All citations quoted in the beginning of each chapter come from expert interviews conducted for the purposes of this dissertation.

Methodology

We can never do something if we don't imagine it first.

~ Institute for the Future

The project connects service design practice and speculative design. While it follows the design process (Figure 2, page 8), it is also based on the Futures Cone theory (Figure 1).

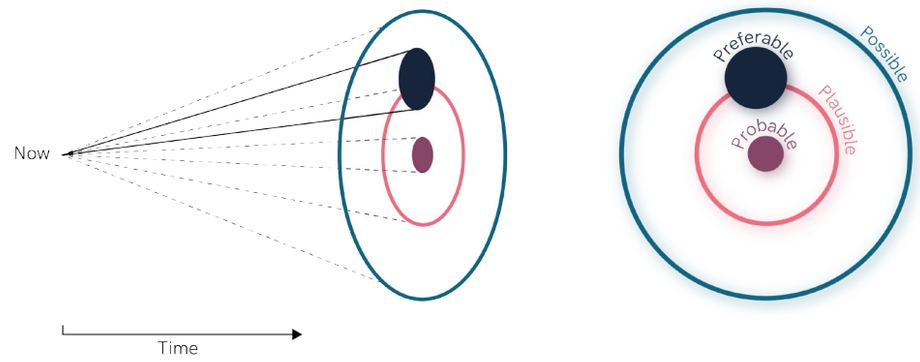


Figure 1: The Futures Cone, adapted and extended from Voros (2003)

The Futures Cone, also known as Plausibility Cone or Futures Vuvuzela (van Gaalen, 2016), is a framework used by futurists and speculative designers to imagine alternative futures. To better understand the concept, the diagram is often compared to a ray of light coming from a flashlight (the 'Now), which lights up the darkness in front of us. The area where the light is the brightest and where most details can be seen represents the 'probable futures', current trends and things that are likely to happen. The wider area where the torch beam becomes blurred and shows less detail, things that could happen are illuminated and are known as 'plausible futures'. As the light spreads further away, it is difficult to perceive any features other than things that might happen, called 'possible futures' (Nicholas, 2013). The Futures Cone also includes 'preferable futures' – what we want to happen – which moves imagination towards the best visions (Hancock and Bezold, 1994). Identifying 'preferable futures' is a practice used among designers to settle on a shared future vision and to design a desired outcome.

This project tries to define a preferable future for pedestrians living among self-driving cars.

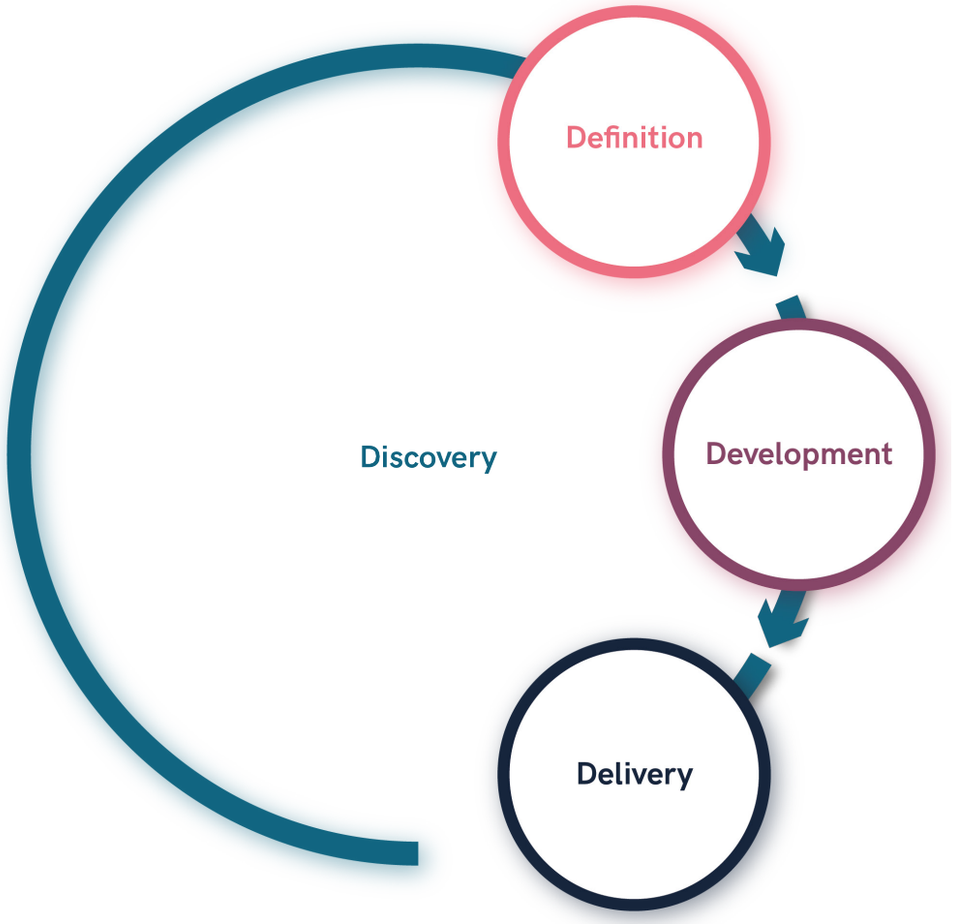


Figure 2: The design process

The dissertation follows a design process based largely on the Double Diamond framework. As shown in the diagram above, the Discovery phase (research phase) continues through the whole process and is present at every stage. For this project involved a significant amount of constant research on technological trends, ethical issues, as well as formal and informal interviews, it was important to emphasise it in the process scheme. Definition phase includes topic scoping, current user journey, online survey and How-Might-We questions. The following Development stage covers design personas, future artifact and co-design session. The last Delivery phase describes concept proposition, prototyping and iterations.

Initial Discovery

As a pedestrian, you have no idea what an autonomous car thinks.

~ Humanising Autonomy

Glossary

Autonomous vehicles – some researchers argue that there is a difference between an *autonomous vehicle* and a *self-driving car*. They say that any car with the autonomy level of 1 or more can be called *autonomous* and *self-driving cars* are only those which do not need a human driver. In this project, however, the notions *self-driving car*, *autonomous vehicle (AV)* and *driverless vehicle* will be used interchangeably and describe the same type of a car – one which does not have a driver.

Transition period – a time in the future when there is a mix of both self-driving and non-self-driving (regular) cars on the roads.

Secondary research

The inspiration for the topic of this project was sparked by the shocking article headline saying self-driving cars may hit people of darker skin tone more often (Houser, 2019).
A thorough research showed that the main reason behind it is algorithmic bias. This initial 'dive' into artificial intelligence and bias, including interviews with experts, allowed for a great understanding of autonomous vehicle operations.

Autonomous vehicles (AVs) are an example of sophisticated artificial intelligence (AI). They run on a very complex set of algorithms and rely on a number of sensors. The main reason for the bias, whether it is based on gender, race, age or other, are biased training datasets which the AI systems are given to learn. And they are biased usually because of human errors and unintentional ignorance towards inclusivity. In the example of biased autonomous vehicles, the training datasets contained a disproportionate number of images of white people compared to darker skinned people (Houser, 2019).

The problem of biased AI is only one of many when it comes to self-driving cars. What distinguishes them from regular cars is, obviously, that there is no need for human driver. And while it undoubtedly could make people's lives more comfortable and eliminate human error – the main cause of car accidents worldwide (Singh, 2015) – it removes the social interactions between drivers and pedestrians. These are very often a vital part of the traffic, e.g. drivers can communicate between each other and agree on one's right of way at a non-signalized intersection. Drivers can also make eye-contact with pedestrians and communicate that it is safe for them to cross (Rasouli and Tsotsos, 2019). Lack of these interactions can significantly disrupt the traffic and cause miscommunication between self-driving cars and pedestrians.

Right now, the technology embedded in the vehicles does not adequately understand people's behaviours. It is likely to fail in many situations, mainly involving pedestrians, with which drivers need to deal on everyday basis. In his article, Brooks (2017) breaks down exemplary situations in which autonomous vehicles would possibly fail. He also considers different road types, e.g. busy shopping street, residential neighbourhood and a dark country road. Brooks (2017) emphasises the fact that each of these places is ruled by different habits and unwritten, conventional nuances which are not understandable to AI. For instance, when thick snow covers narrow pavements on a residential street, people sometimes choose to walk on the side of the road and expect drivers to pass them but also be respectful of them. Would the safety-focused self-driving cars overtake them or follow the person slowly, eventually creating a traffic jam? What is more, cars adjusted to commuting in one type of conditions might not be able to deal with other environments (Brooks, 2017). To solve the bad communication problem, some researchers think pedestrians will have to change their behaviours into less erratic in order for autonomous vehicles to actually work. It is also suggested that people should be provided with proper education and guidance regarding self-driving cars (Kahn, 2018).

Examples of artificial intelligence are often a subject of endless moral considerations, including the above-mentioned bias. Ambiguous and unexpected situations on the roads pose questions about ethical behaviours of autonomous cars. They do not have the human common sense which can often help avoid accidents, even if it means braking the law, e.g. a child running into the street after a ball forcing the car to cross the double yellow line. Instead, the vehicle would rely on its confidence level and first determine, with high level of certitude, if the object (child) in its path is actually alive. Then, the car would check if there are no other living objects in its way in case it crossed the double line. In case of an unavoidable accident with inevitable victims, self-driving cars are expected to optimise the outcomes of the crash and minimise harm (Adalid, Lant and Luhman, n.d.). This subject, sometimes called 'the driverless dilemma', is explored by MIT Media Lab in a survey named the Moral Machine (Moral Machine, 2016). Respondents are given a choice over whose life an AV should spare in 13 very specific scenarios including a set of variables, such as old or young, rich or poor, man or woman, more or fewer people, passenger or pedestrian. The results show that answers vary significantly based on people's culture and country of origin, although a general tendency was to spare humans over pets and groups over individuals (Maxmen, 2018). What if the optimisation of outcomes will be up to self-driving car programmers? What if they program the algorithm to swerve into a specific type of people?

There is also another angle to the autonomous vehicle ethics. Some experts believe self-driving cars will be victims of pedestrian bullying and pranking. Given the high level of safety and predictability of AVs, people will take advantage and not feel threatened by the vision of being run over by a car. They will burst into the streets and by this frustrate autonomous car passengers, eventually making the vehicles less desirable in urban areas (Claburn, 2016).

While the cars do not understand people, humans do not understand them either. Communication between the two is crucial for the success of autonomous cars and, above all, for the successful street crossing. The main challenge pedestrians will deal with is figuring out whether an approaching car is going to stop for them or not. There is a number of conceptual projects and studies suggesting ways to deal with the issue, mainly proposing external human-machine interfaces (eHMIs) (de Clercq et al., 2019). For instance, Chang, Toda, Sakamoto and Igarashi (2016) propose digital eyes installed on the vehicle to make eye-contact with a pedestrian. This would help them recognise the vehicle's awareness of their presence (Chang et al., 2016). Similarly, Lyft suggested placing messages for pedestrians on vehicle windows (Aouf, 2018).

Despite the numerous issues mentioned, tech organisations such as Google, Apple, Audi, Tesla, Toyota, to mention just a few, strive to create a fully autonomous vehicle. The industry recognises 5 levels of car autonomy (Figure 3), with level 3 being the only achievable level so far. Experts and researchers say it will be at least a 10-12 years before private buyers can buy a fully autonomous car. So called 'robotaxis' – for example Uber ride-sharing cars – might not be publicly widespread until 2025 (LeBeau, 2019). It is unclear when autonomous vehicles could become a commonplace in London.

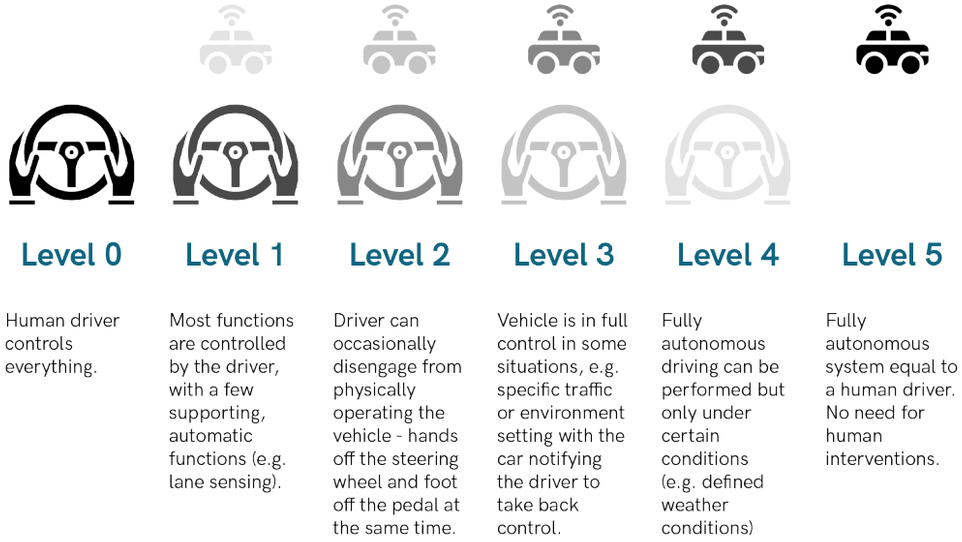


Figure 3: Levels of autonomy; based on Brooks (2017)

Stakeholder map

Positive and successful interactions between autonomous vehicles and humans would benefit many stakeholders, especially pedestrians. It is also in the interest of AV manufacturers to develop or adopt a solution which provides good human-car relationship. The following map shows stakeholders who would benefit from and who can contribute to a positive interaction between pedestrians and self-driving cars.

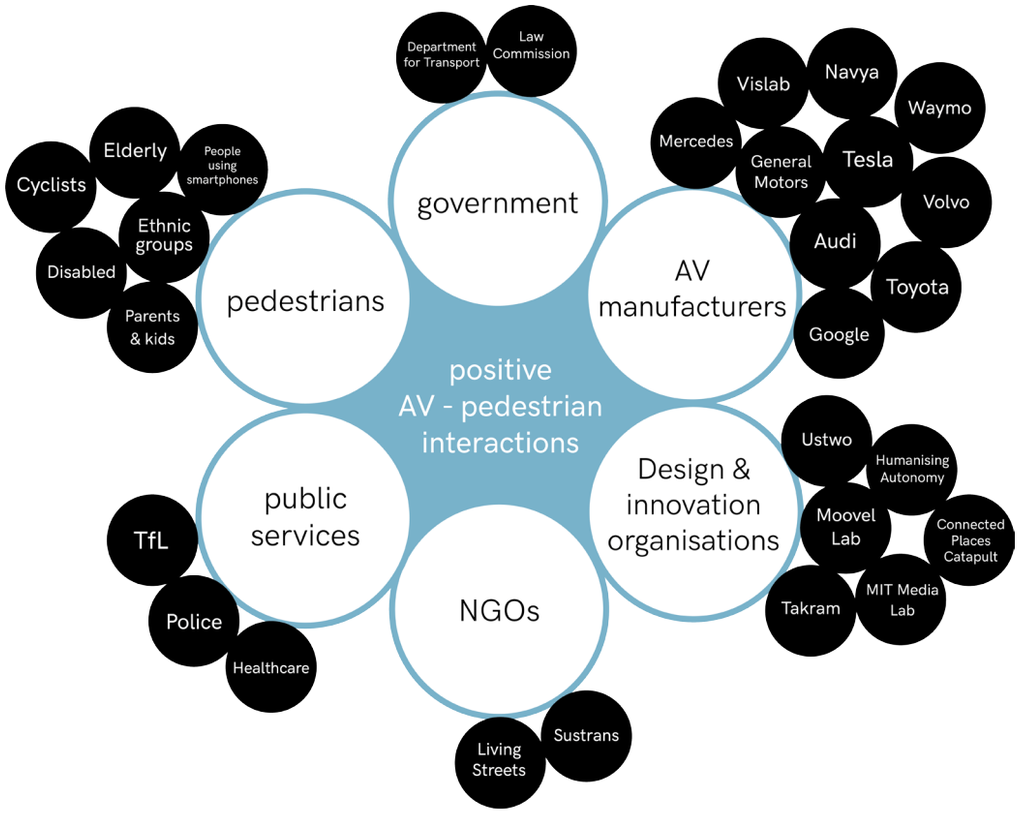


Figure 4: Stakeholder map

Definition

Pedestrians are, in a way, passive users of autonomous vehicles

~ Digital Catapult

Topic scoping rationale

The research started from the very broad topic of biased Artificial Intelligence and technology. It was then narrowed down to autonomous vehicles – an example of complex AI – with regards to pedestrians (Figure 5).

The choice to focus on pedestrians (and not, for example, on passengers) was motivated by the fact that they seem to be perceived by the automotive industry as an obstacle rather than an integral part of the traffic. Even though self-driving car manufacturers promise a significant increase in the safety level on the streets, it is widely admitted that the vehicles do not understand human behaviours, at least not yet. Pedestrians are rarely the subject of discussions, with the main attention given to passenger journey and comfort. Some experts believe pedestrians might have to adjust or learn new behaviours in order to stay safe on the street. What is more, the transition period will certainly be very challenging for pedestrians, and possibly quite long as well. On the other hand, it is speculated that people will deliberately disrupt autonomous cars' journey – making the otherwise bright future of ride-sharing economy slightly dim.

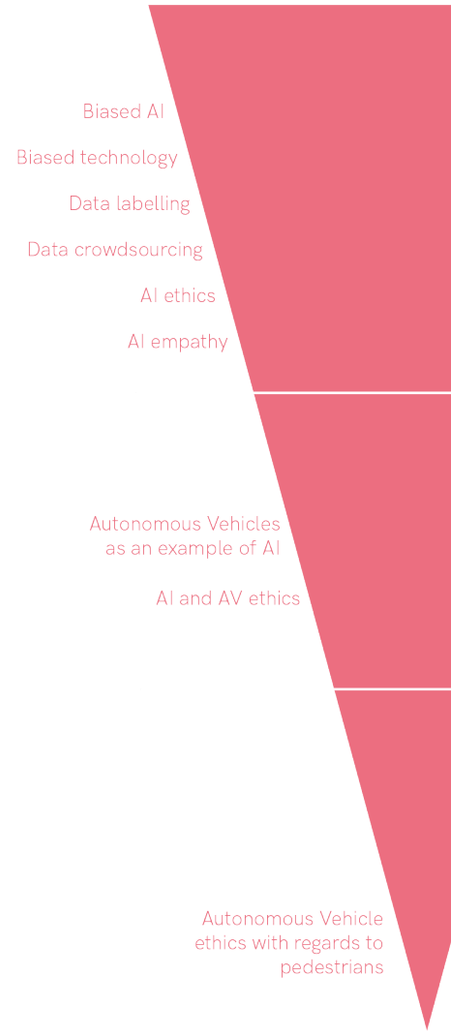


Figure 5: Topic scoping cone

There is a lot of uncertainty when it comes to the future of getting from point A to point B by foot, especially while being accompanied by both self-driving and regular cars. Below is a comparison of pedestrian journeys in 2019 (Figure 6) and in the uncertain future (Figure 7).

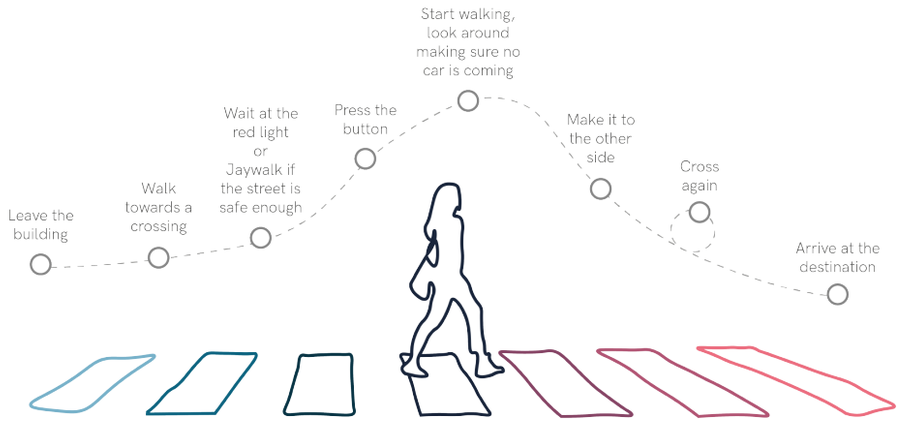


Figure 6: Current user journey of street-crossing

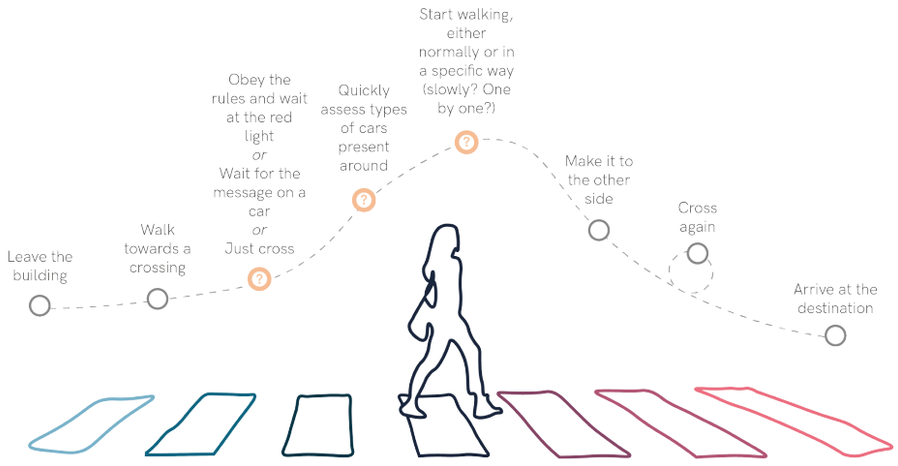


Figure 7: The future journey of street-crossing with the unknowns

In the future, the everyday process of street crossing will probably look differently to how it does now. It is possible, and quite commonly believed, that the driverless vehicles will be so safe that people will be able to just cross the street when they want to, without the possibility of getting harmed. This vision, however, could be easily challenged, especially when thinking of the transition period in London. People and the cars will have to collaborate to avoid a breakdown of the traffic system where pedestrians start walking on the roads feeling 'too' safe. Additionally, the presence of both regular and self-driving cars will likely cause a lot of confusion and possibly result in pedestrian accidents related to that. On the other hand, speculations and design concepts often re-imagine the design of the car to support communication with pedestrians. Vehicles get added features like those mentioned in the previous chapter – a displayed message saying 'you may cross now' or digital eyes. There are many possibilities but not one agreed solution (yet), which might increase the pedestrian confusion.

Online survey

People's opinions on the future of being a pedestrian next to self-driving cars were gathered in an online survey conducted specifically for this project (questions in the Appendix). The short questionnaire was distributed through social media and received 82 responses. The answers come from an impressive mix of age groups and a perfect balance of genders. The questions explored people's familiarity and current attitudes towards self-driving cars. Most importantly, it was investigated whether people would be willing to change their current street-crossing habits in the name of safety. Specific statistics are shown in the infographic (Figure 8).

About 80% of the respondents admitted that they would avoid the streets, feel anxious and scared if the autonomous cars were more likely to hit their demographic group than others. About 1/4 of them also declared readiness to protest against the car manufacturers.

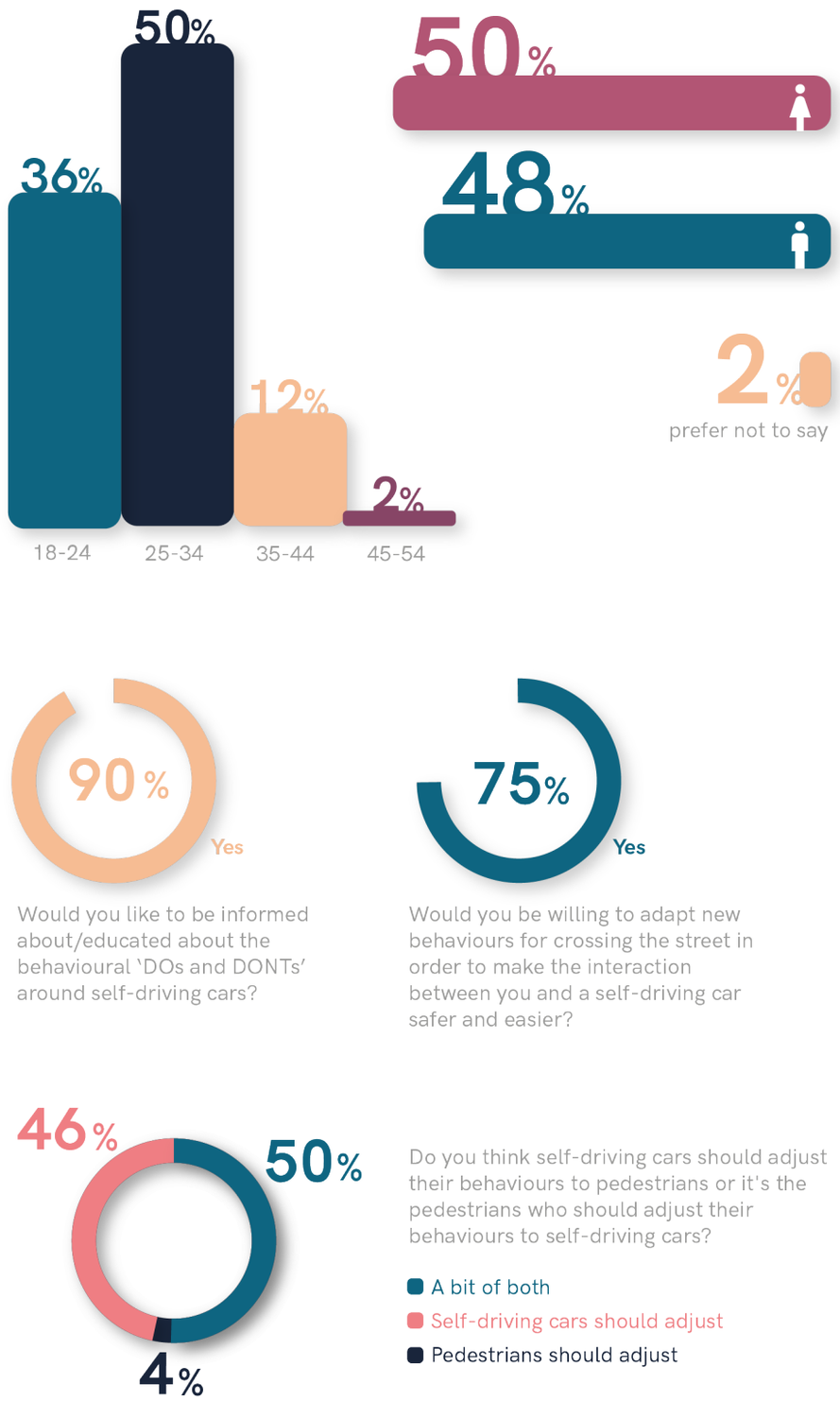


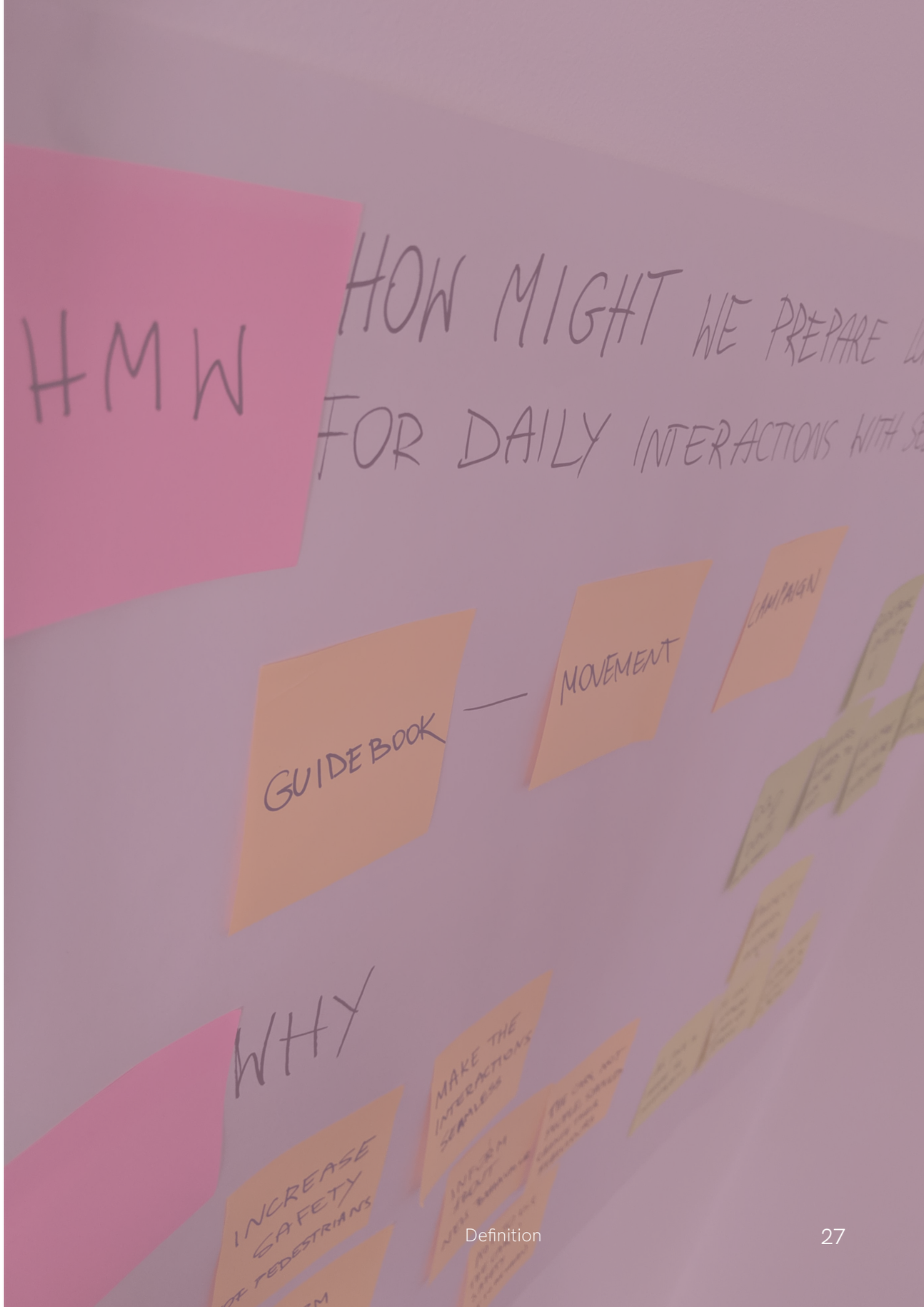
Figure 8: Significant data received from the online survey

How Might We question

Research findings both from the Discovery and Definition phases were used to synthesize How Might We statements. In the design field, HMWs work as starters for brainstorm and should give room for a variety of ideas within a specific topic scope. The project looks specifically at the future of London pedestrians during the transition period.

How might we prepare London pedestrians for daily interactions with self-driving cars?

How might we assure a good relationship between self-driving cars and pedestrians?



Development

Autonomous cars should be added a bit of irrationality.

~ Comuzi

Design Personas

Information gathered through the online survey and thorough desk research allowed for creating four design personas. This tool was used to better understand the needs and fears of the society on a personal level. All the personas come from current times and express concerns about the future. Each persona is a London pedestrian and represents different age group. Additionally, each of them embodies a certain issue related to the future of autonomous vehicles.

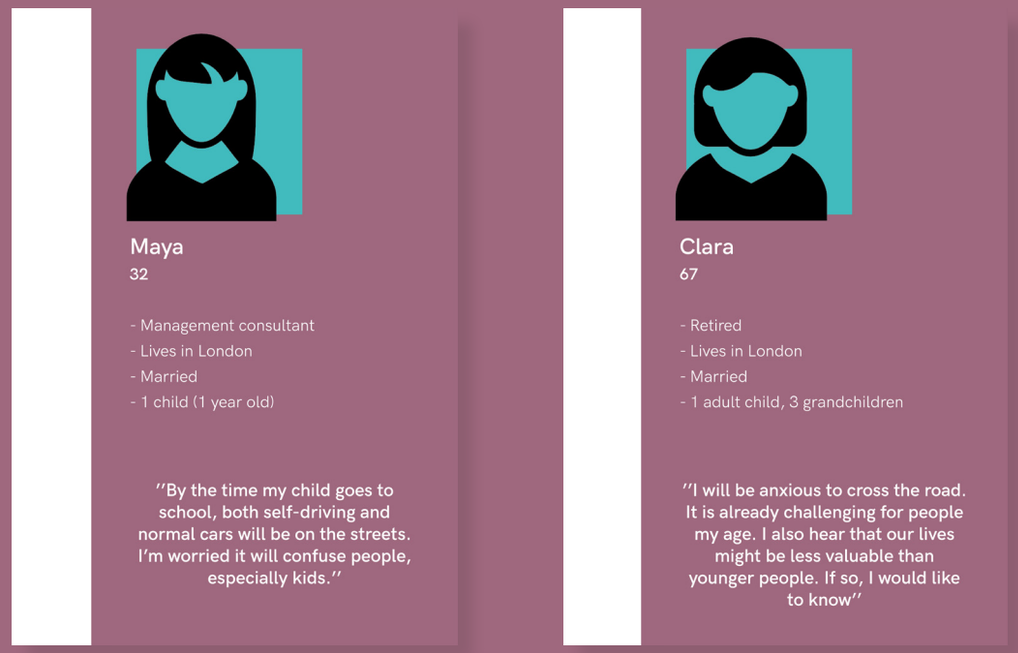
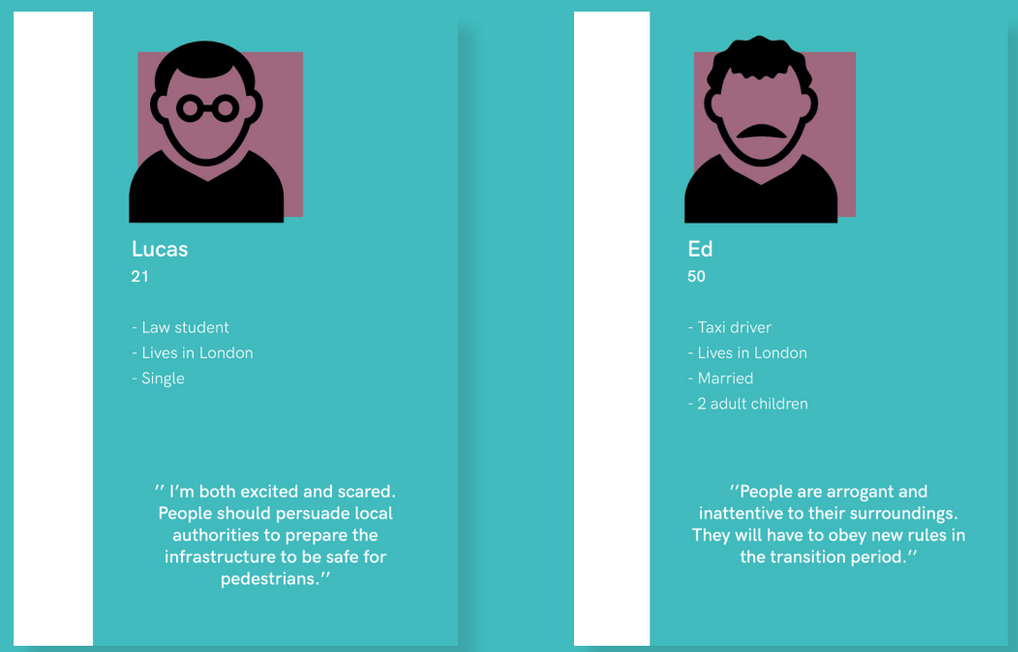


Figure 9: Four design personas



Maya is a young mother and expresses concern regarding the transition period confusion. Ed, a taxi driver, points out jaywalkers and hints on the future of autonomous taxis. Clara is worried about future street crossing and embodies the possible 'driverless dilemma' victim. And lastly, Lucas emphasises infrastructure change but also, as a law student, hints on the future of regulations connected to autonomous vehicles.

Future artifact - conversation starter

To help better imagine and connect with the proposed future scenario, it is worth creating future artifacts. An artifact is an item coming from the future, which a casual observer might mistake for a contemporary object and find out its fictional features only after closer inspection (Bleecker, 2019).

This project benefited greatly from The Times article coming from 2025 which was inspired by people's declarations in the online survey. It describes the first ever protest against self-driving cars in London. The short, cover page article features quotes from concerned pedestrians who express their frustration with car manufacturers and the government. They feel ignored, scared and unprepared for interactions with the machines. It also features statements of annoyed passengers who wish pedestrians were educated on how to behave next to self-driving cars, especially when it comes to disrupting their journey. The article emphasises lack of awareness in the society, general transition period confusion and disappointment with those in power. It is underlined at the end, however, that London citizens do see the autonomous car potential, yet demand the tech companies and governments to act more in favour of humans.

The article was later used in a co-ideation session where participants tried to imagine what would have to happen in order to stop people from protesting.

THE TIMES

Max 21C, min 10C | Monday September 22 2025 / thetimes.co.uk / No 90134 | £1

For the first time London citizens protested against self-driving cars and ignorance of government and autonomous car manufacturers towards pedestrians.

Cross with the cars

London pedestrians protest against losing their rights to AVs

Alicja Halbryt

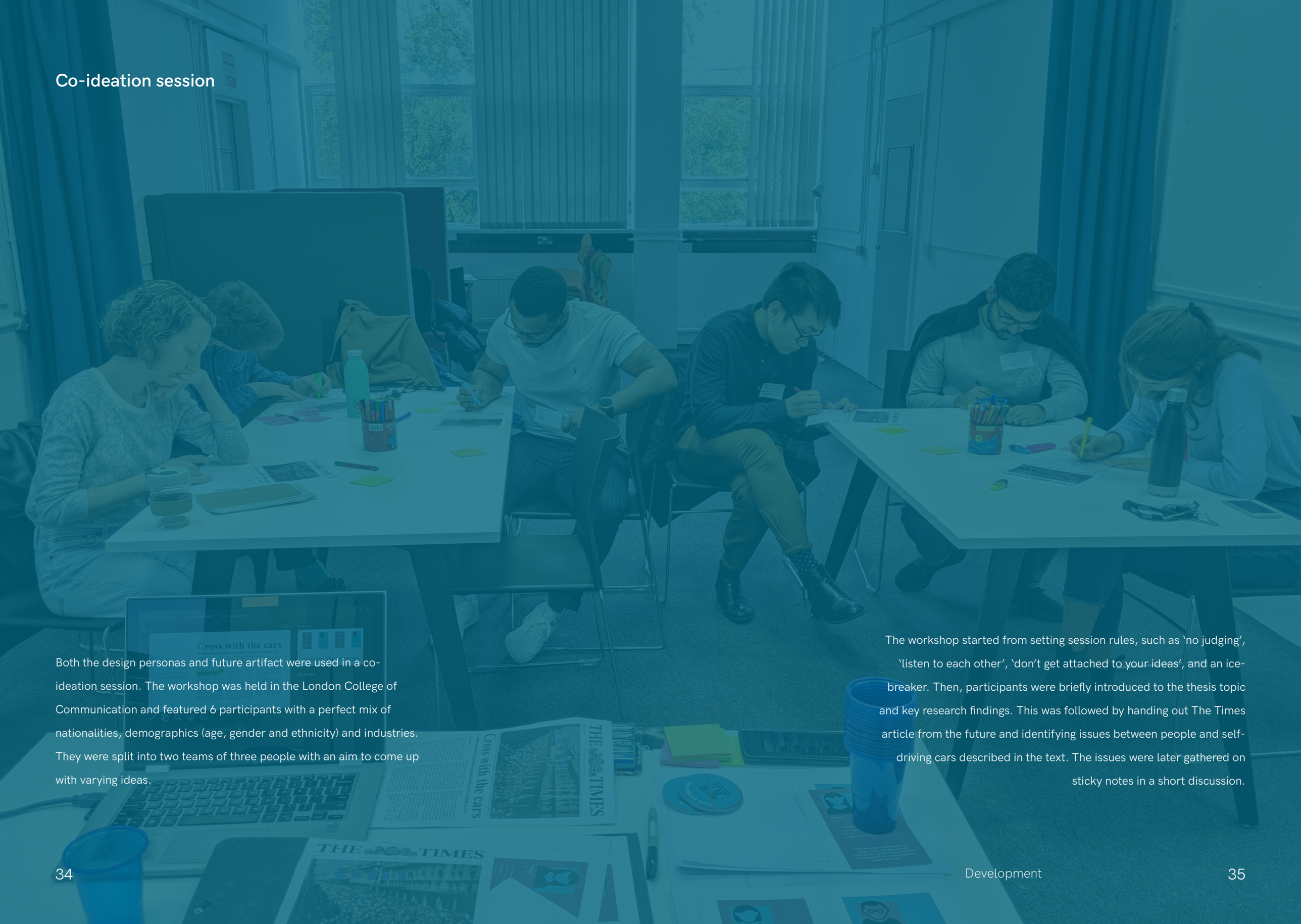
Last Sunday, thousands of Londoners gathered on the city streets. They expressed their concern and disapproval towards self-driving cars. The negative attitude has been growing ever since the AVs appeared on London streets. Citizens claim the cars cause confusion and pose a threat to children and the elderly. 'It is chaos to me. Some cars stop when I want to cross, some don't. It makes me more vigilant and scared when I'm near them' said one of the protesters. The confusion is compounded by the presence of both self-driving and non-self-driving cars. Pedestrians often find it tricky to distinguish the two. It has resulted in many minor, and a few major, accidents involving pedestrians. 'We wish the government or AV manufacturers had given us any kind of guidance on how to behave on the street. The society clearly needs this' said another striker. Many people present on the protest accused the autonomous car leaders of mis-representation. They claim to had been promised safer streets, yet received the opposite. Some believe London is not ready for the implementation of the technology. Experts on AI and AVs say that in order for the cars to co-exist with people, the society has to start obeying new rules. However, even though AV developers produced a few 'know-how' commercial spots regarding street-crossing, the protesters find them vague and not practical.

Among pedestrians, owners of AVs and users of autonomous taxis were present too. They also expressed their annoyance towards lack of pedestrian awarness. According to one of the protesters, 'sometimes when people are certain there is an AV on the road, they burst into the street. The car slows down and stops multiple times to keep the jaywalkers safe. It significantly disrupts the passenger journey'.

The most serious accusation aimed at the AV producers is the infamous 'driverless dilemma' case. The recent leakage of Toyota's data exposed the probability of AVs being more likely to drive into certain groups of people. The car manufacturer denies the allegations, yet the fears in the society arise. 'I heard the cars might not spare my life because I'm old. I don't want to die this way and that's why I'm here' said an elderly protester.

Most of the protesting Londoners still believe the technology has a potential. They especially admit the good impact it has on the air quality in the city. Yet, they demand the government and tech companies to act in favour of pedestrian safety and comfort. 'It is like a malfunctioning relationship - we don't understand the cars and they don't understand us. It can't lead to anything good'.

Co-ideation session



Both the design personas and future artifact were used in a co-ideation session. The workshop was held in the London College of Communication and featured 6 participants with a perfect mix of nationalities, demographics (age, gender and ethnicity) and industries. They were split into two teams of three people with an aim to come up with varying ideas.

The workshop started from setting session rules, such as 'no judging', 'listen to each other', 'don't get attached to your ideas', and an ice-breaker. Then, participants were briefly introduced to the thesis topic and key research findings. This was followed by handing out The Times article from the future and identifying issues between people and self-driving cars described in the text. The issues were later gathered on sticky notes in a short discussion.

Next, each team received a set of 2 personas – Maya and Ed, Clara and Lucas – and was asked to analyse and empathise with their needs and fears. The session then moved on to ideation task – the Crazy 8. For 8 minutes participants had to use all the information they received till now, including persona features and the HWM question, and come up with 8 different, radical, crazy, positive or negative, quick ideas. They were shown current and possible future traffic design elements for more inspiration. Later, all the participants got a chance to share their ideas with others.

After brainstorming, the workshop moved on to the concept development stage. Teams were asked to choose one idea from the Crazy 8 task, or merge a few, which seemed the most feasible or simply the most fun. Each group was given two different sheets of paper and 12 stakeholder cards designed to support the development process. The first sheet featured questions about the concept itself which would help define it better. The stakeholder cards were used to answer a question from the first sheet about the service provider or parties responsible for its delivery. The second sheet included an image of a street crossing and could be used to visualise a concept if needed (Figure 10). After 30 minutes both teams gave short presentations on their ideas.

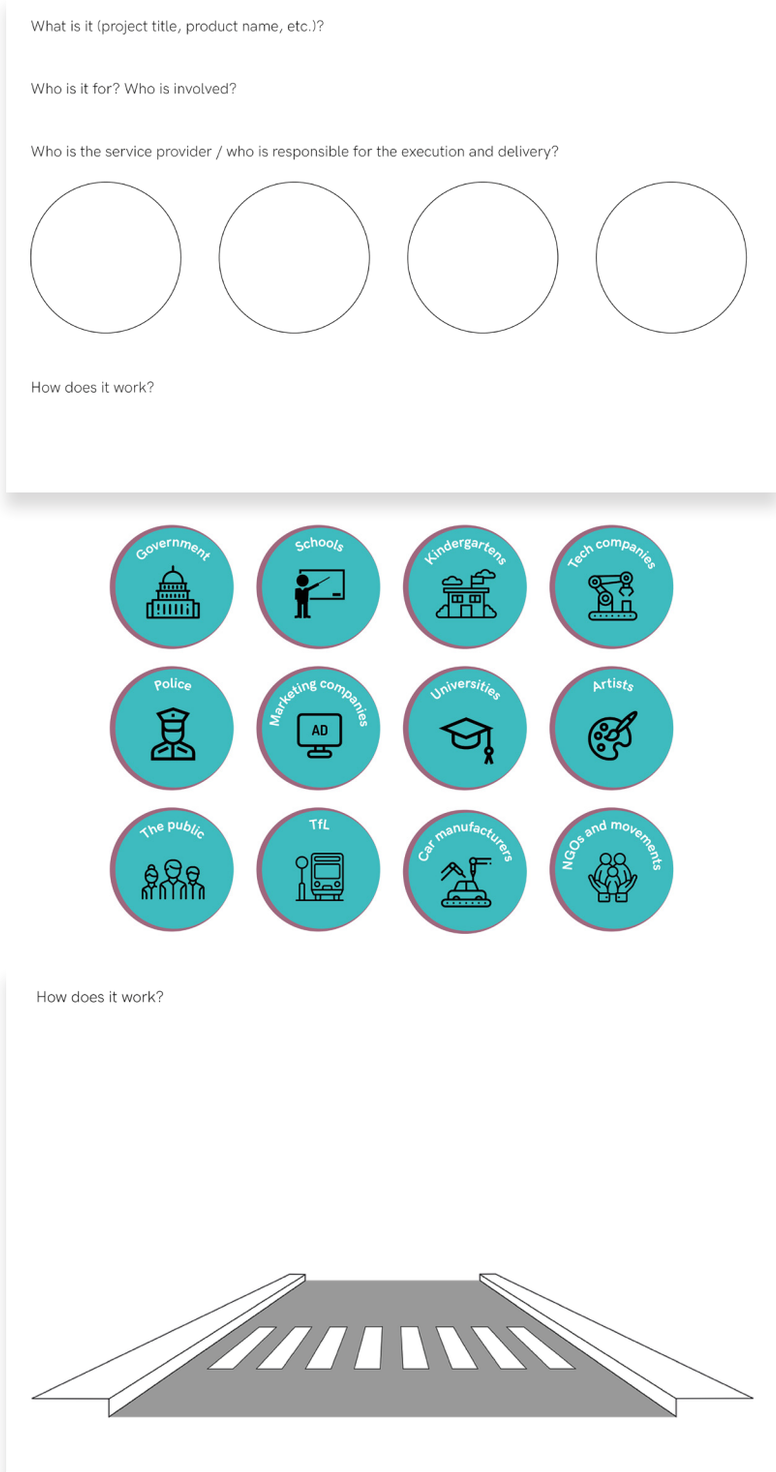


Figure 10: Concept development task

There are a few key insights that can be drawn from this co-ideation session. A lot of focus was given both to infrastructure and education. One team developed an idea of cars driving in underground tunnels, leaving car-free open spaces to people. Interestingly, this concept in a way gives up on building the human-car interaction and completely separates the two. Although it would certainly eliminate the risk for pedestrians and make cities much more friendly to live, it is highly improbable, at least in the existing cities in the near future. The other group tried to propose an educational tool for pedestrians and prepare them for interactions with the cars. The main problem they encountered was inclusion. Running a course, a 'pedestrian school' or proposing an educational app would very likely exclude the disabled, elderly, young children and leave these groups at risk and less aware.

Through the whole co-ideation session participants came up with numerous brilliant ideas. From robot crossing assistants and 'Dumb Ways to Die' style campaign to smart glasses helping distinguish car types and an app with a special map for pedestrians. Ideas proposed were synthesised and used to create the major concept.

Delivery

Visually impaired people or people on wheelchairs might find the pedestrian mode particularly useful.

~ Centre for Connected and Autonomous Vehicles

Speculative outline of the future

Building a speculative design project requires a vast amount of research on trends and signals. Having a good understanding of what the future might bring is crucial for successful development of a realistic project. It is especially important when working on a scenario which is not set in a far future. In order for the project to provoke discussions and create an impact, it needs to feel relatable to the audience (Auger, 2013). The following section will discuss assumptions made about the future and set a background for the speculative service.

In about 10 years time, majority of vehicles on London streets will be used for business, deliveries and taxis. Ride-sharing economy will thrive and become so cheap and accessible many people will realise they do not need a car anymore (Walmsley, 2018). While part of the vehicles will be self-driving, regular cars will also achieve some level of autonomy (Brooks, 2017). Thanks to the growing trend of making cities friendlier for pedestrians and cyclists, people will be able to enjoy a bigger number of wide pavements, bicycle routes, and pedestrian crossings. Additionally, there will be numerous pedestrian-exclusive spaces and car-free market streets (Smartcitiesdive.com, 2015), such as Oxford Street (Living Streets, 2019). It will encourage people to commute through walking or cycling.

Initial concept

The idea for the service of the future is a pedestrian mode on personal devices. The feature would be part of operating systems and, ideally, it would be developed together with autonomous car manufacturers. This would allow the pedestrian mode to communicate without fault with all the car brands. The mode makes pedestrians visible for autonomous vehicles. It does so through enabling location, 5G and different sensors in a device, and shares it with the driverless cars (Figure 11). This allows them to know where a person is, which direction they go to and with what pace they move (including the time spent standing). It means the self-driving cars can predict pedestrian's next moves and act accordingly to keep them safe. The data is also shared with pedestrian crossings with traffic lights. The reason for only larger crossings having the data access is that pedestrians have a right of way on any other crossing type anyway. Additionally, thanks to the pedestrian crossings and the cars sensing people held at the red light, it is possible to speed up the wait for green light.

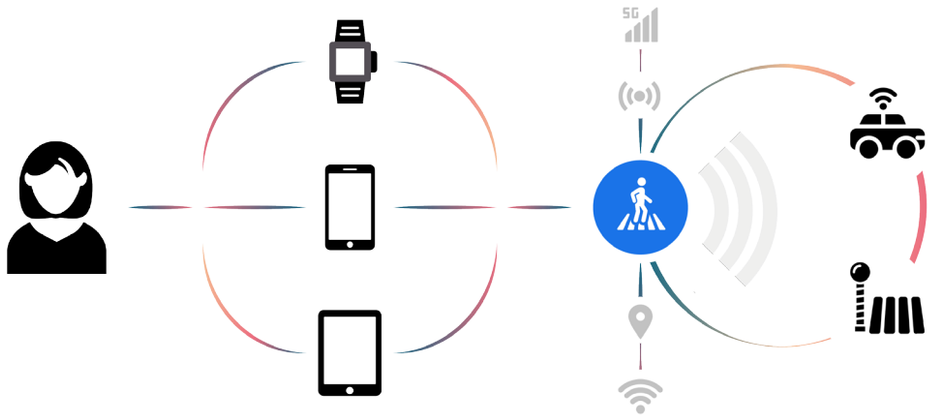


Figure 11: An outline of pedestrian mode operation

Because the very high level of on-street safety provided by the pedestrian mode could result in pedestrians walking on the roads and crossing at any time and place, the initial concept considered either a penalty system for those who disrupt the traffic or a reward system for people who follow the traffic rules. It even included a new definition of jaywalking:

jaywalking is when a person enters the road in a place and time other than pedestrian crossing and green light, and by this forces an autonomous vehicle to stop or significantly slow down.

The service would only be successful if people were made aware of the self-driving car related issues before the pedestrian mode is introduced in the society. Through this, people would feel the need to own something that protects them, or to know how to remain safe. Therefore, the pedestrian mode would become a desired feature in people's lives. The campaign would be run by the autonomous car manufacturers and tech giants – pedestrian mode creators. It would consist of ads spread around the city and public transport, social media and traditional media.

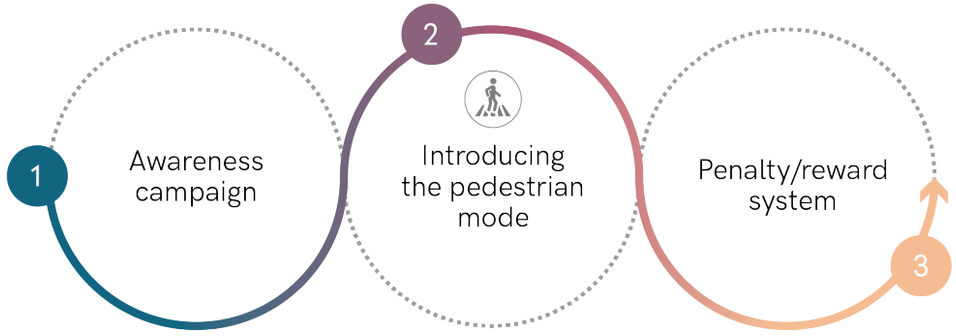
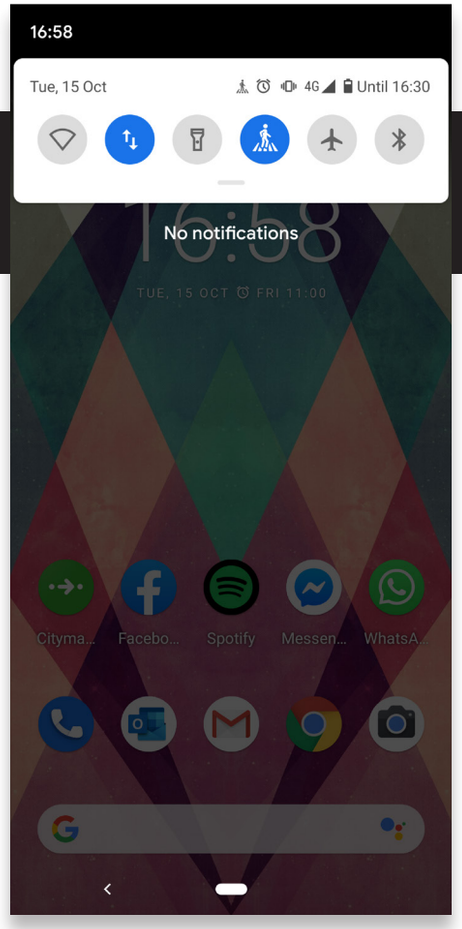


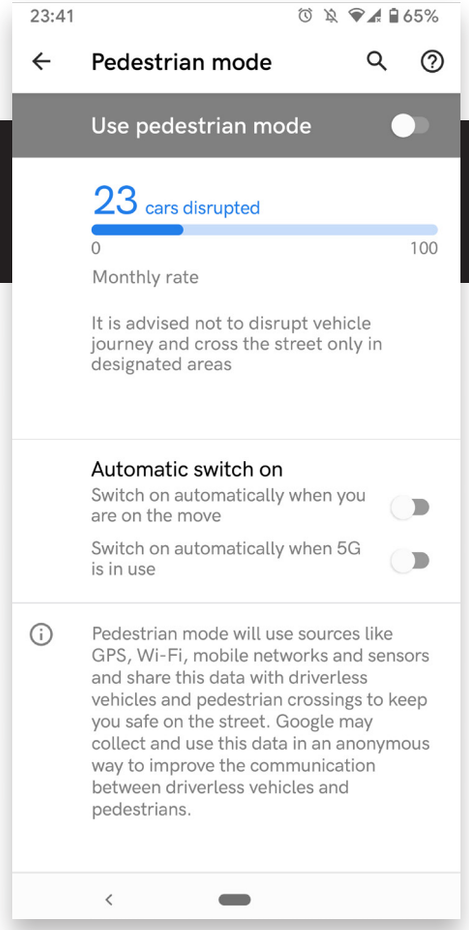
Figure 12: The flow of the initial service concept

Prototypes



The swipe-down menu allows to quickly switch the pedestrian mode on or off.

A person is sent a notification whenever they force an AV to stop or significantly slow down. It aims to keep people aware and mindful of passenger journey.



Users are shown a monthly rate of cars which they have disrupted. When they exceed the limit, they face a fine. It aims to stop people from jaywalking. Automatic switch on setting allows the mode to switch on and off automatically when the person is out, on the move or uses 5G.
The settings page also includes information about data processing.

Iteration

Other than strictly maintaining people's safety, the penalty and reward system would not act in favour of pedestrians, who are the main subject of this project. A structure like this is a slightly dystopian concept which could be compared to the infamous social credit system in China (Ma, 2018). It was also very difficult to figure out what kind of penalties or rewards the system should include. Should they be point penalties or monetary? If so, the government should also be involved. Would the fines apply to children as well? If not, wouldn't some of them start 'pranking' the cars? Maybe a reward could be an autonomous taxi discount? Maybe the pedestrian mode could stop working completely if a person disrupts too many cars? Additionally, penalty system would have to take into account the distance travelled and the frequency of travel in order to be fair - disrupting two cars at a long distance cannot equal disrupting two cars at a short distance.

The idea was consulted and tested with many individuals. It was also discussed with Sustrans charity, an organisation working towards easier walking and cycling. They strongly prioritise people's comfort and safety on the streets and encourage healthy lifestyle through active commute. Sustrans' feedback on the pedestrian mode concept was both positive and negative. The sole idea of giving people a tool which increases safety and speeds up the waiting time at crossings was regarded as very beneficial. On the other hand, the penalty/reward system introduced with an aim to stop people from jaywalking was considered unfavourable for pedestrians. The charity's stance is that it is the humans who should be prioritised and move freely around the city, not vehicles. It was also mentioned that some groups of people and places should be treated as exceptions – for example autonomous vehicles should always stop and not be considered distrupted around schools and kindergartens.

This point of view influenced further idea development. As this project aims to put pedestrians first and design a solution beneficial to them, it was important to transform the concept to be even more pedestrian-centred. Additionally, taking into account the future trends such as less vehicles on the roads due to the increase in ride-sharing economy, more car-free spaces in cities or developing car-only roads, it might turn out unnecessary in most cases to resort to fining people for disturbing the traffic. It might even result in people refusing to use the pedestrian mode at all. And lastly, a solution of that sort could be one of the reasons for pedestrian protests described in the future The Times article. In that case, a less severe concept was developed.

Final service concept

To illustrate the idea in the most comprehensive way, Google will serve as an example of a company which could implement the service concept. Organisations which could also aspire to include the pedestrian mode in their offering are Apple, Microsoft, and any company producing operating systems for personal devices, including those yet to be established. Undoubtedly, the best outcomes and functioning of the feature would be achieved if autonomous car manufacturers also contributed to the mode's development. This makes Google, Apple or Microsoft the best current 'candidates' to implement a feature enabling communication between self-driving cars and pedestrians, as they are leaders in autonomous car development too.

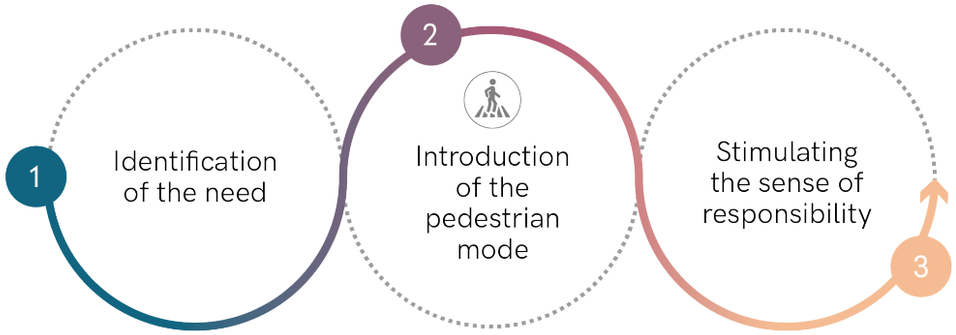


Figure 13: The flow of the final service concept

Identification of the need

The final flow of the service was slightly iterated. The first step is aimed at building society's awareness about self-driving cars and possible risks that they pose to pedestrians. The campaign should start along with autonomous cars making their first appearance on London streets. In a way, it seeks to identify a new need in the society – a need to maintain safety, to increase one's visibility and to communicate infallibly with the autonomous vehicles. It would include ads distributed around London's public transport and streets, as well as online ads, posts and traditional media.

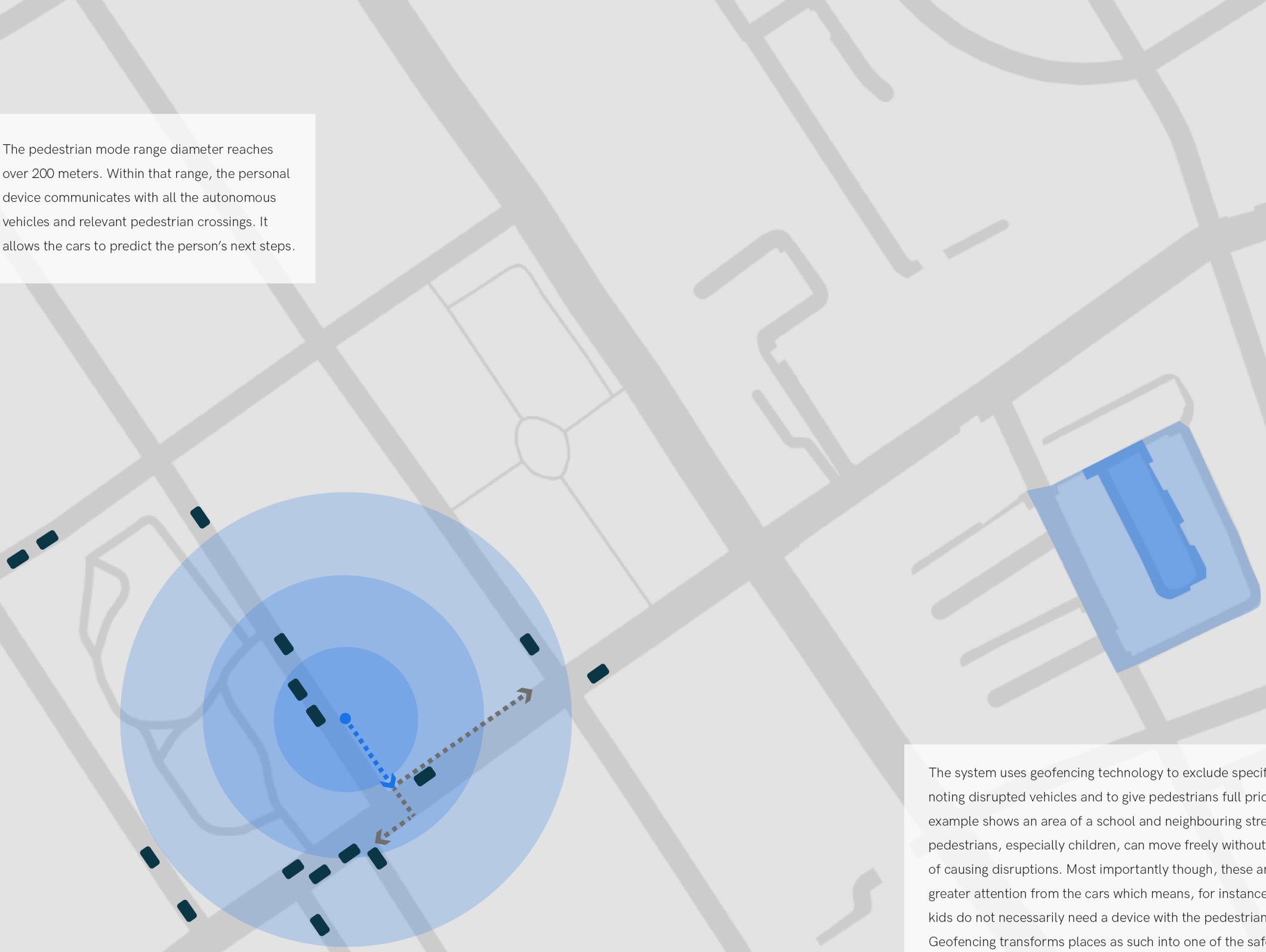
The main reason to raise general awareness about self-driving cars in the society and helping people acknowledge that the autonomous future might be tricky for pedestrians, were the online survey responses. The number of respondents who declared they would be willing to learn about how to behave around self-driving cars shows the public's need to remain safe and to know how to achieve that.

An ad at a bus stop aims to raise awareness about the importance of pedestrian visibility to self-driving cars

Introduction of the pedestrian mode

Instead of providing a guidebook or instructions on how to act on the street, which would be the obvious solution for the online survey responses, people would first find out about the possible risks and identify their needs through the campaign. Then, they would be offered a tool to achieve a high level of safety, which would answer their needs. This concept eliminates the necessity to learn new, sophisticated behaviours which would give the utmost priority to self-driving cars and make people feel that it is them who need to adjust, not the cars. The proposed pedestrian mode increases people's safety and visibility to the maximum without requiring them to stay over-alert.

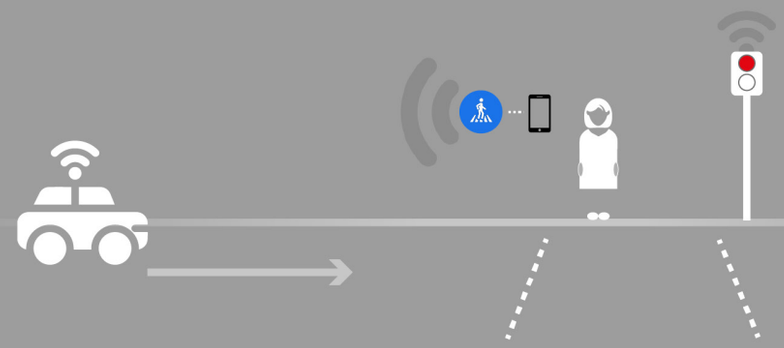
The pedestrian mode range diameter reaches over 200 meters. Within that range, the personal device communicates with all the autonomous vehicles and relevant pedestrian crossings. It allows the cars to predict the person's next steps.



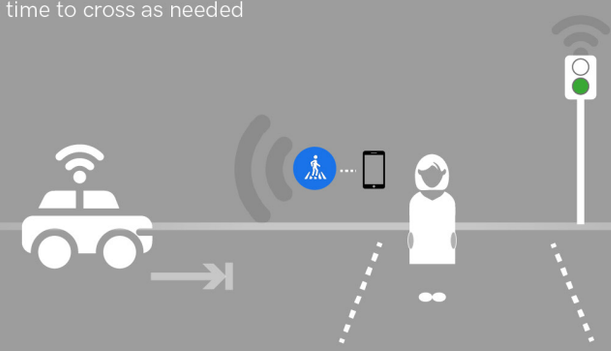
The system uses geofencing technology to exclude specific areas from noting disrupted vehicles and to give pedestrians full priority. This example shows an area of a school and neighbouring streets where pedestrians, especially children, can move freely without being notified of causing disruptions. Most importantly though, these areas require greater attention from the cars which means, for instance, that forgetful kids do not necessarily need a device with the pedestrian mode on. Geofencing transforms places as such into one of the safest in the city.

Shorter wait

1 10-second wait at the red light is sensed both by the car and the pedestrian crossing with traffic lights



2 Change of lights, car stops, giving the person as much time to cross as needed

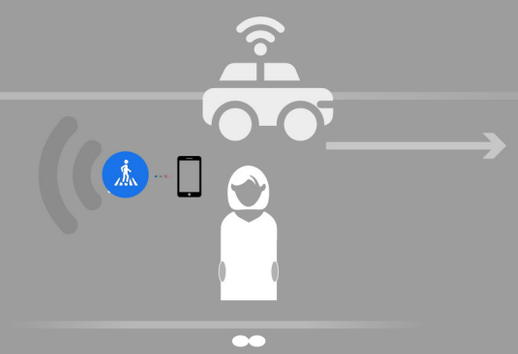


Car speed adjustment

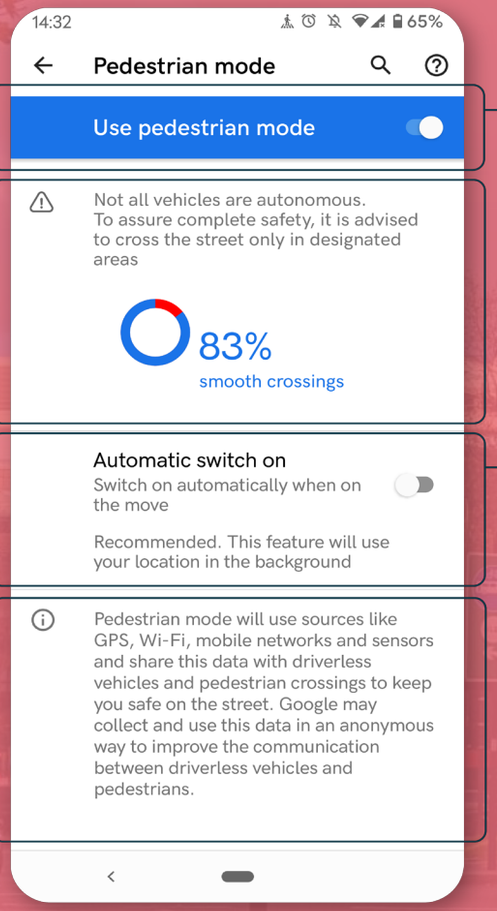
A person who is about to jaywalk (cross not at a pedestrian crossing) is sensed by an approaching car 1

Car adjusts speed 2

Smooth crossing - both the car and the person do not need to stop 3



Settings page



Switch the pedestrian mode on and off

Warning about risks of the transition period

Users can see the percentage of successful pedestrian crossings - crossings that were smooth and undisturbed both by the cars and the person

The mode can be set to switch on automatically when the device senses that the user is out on the street and moving

Information about data usage and privacy

Pedestrian mode is available on any device with an operating system which supports this feature. The tablet and smartwatch show the simplicity of the mode and its unobtrusive nature.

Other possible items featuring the pedestrian mode could include smart jewellery, smart glasses, digital tattoos.

A swipe-down menu and and icon on the top of the screen indicate the pedestrian mode is on.

The pedestrian mode will be available on the newest personal devices, and later through system updates. When purchasing the device, in this case Google Pixel 19 smartphone, customers will receive a welcome message placed on the box regarding the feature. It aims to build a good relationship with the person and encourage them to use the pedestrian mode.

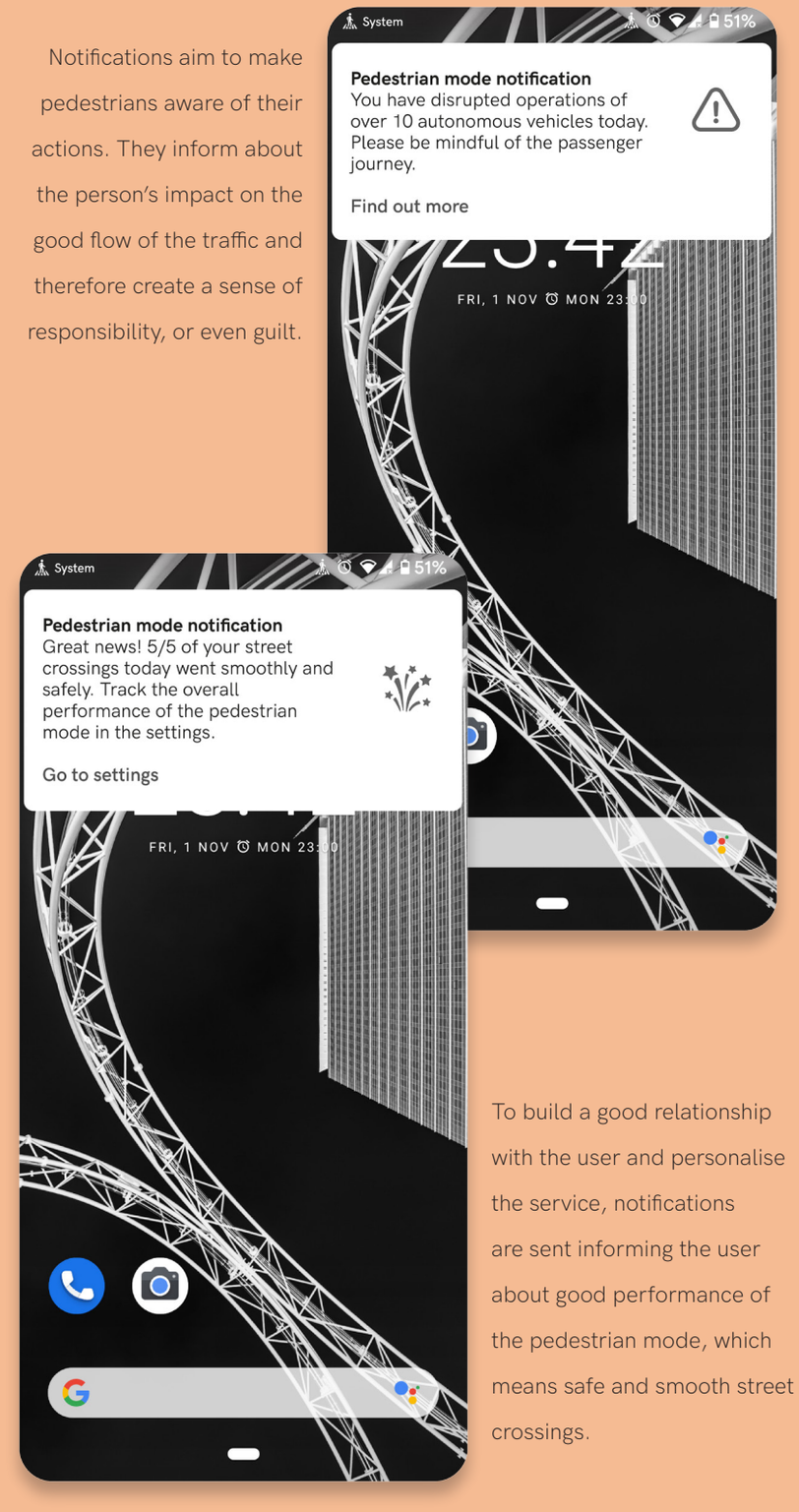
Stimulating the sense of responsibility

The last step of the service is about stimulating the sense of responsibility as well as empathy towards other commuters. Instead of warning and penalising pedestrians for disrupting autonomous vehicles, they will receive notifications asking to be mindful of the passenger journey. Notifications will be sent when a person notoriously disrupts the cars, that is when ten or more cars are forced to stop and give way to a pedestrian in an undesignated area. Disruption will also be noted when a car needs to wait for an extended period of time for a person to leave the road (perhaps having a chat with a friend long unseen in the middle of the lane).

Certain situations will not count as disruptions, for instance when the interaction happens in a previously mentioned, geofenced area, or when a self-driving car does not transport any passengers (it is possible that it will be clearly indicated whether or not an AV is empty by displaying this information on the car).

Overtime, it has been recognised that there are certain groups of people who should be given the utmost priority over the cars. This group includes the most vulnerable pedestrians – people with disabilities and various impairments which do not allow them to move on the street freely. Without a doubt, these pedestrians should not be accounted for causing disruptions to the cars. It is possible that in the future sensors in personal devices will be so greatly developed that they will be able to sense if a person has a disability or not. Additionally, the pedestrian mode allows people to take as much time as they need to cross the street. Nevertheless, the aspect of vulnerable pedestrians is an area that would require special attention in the future iterations.

Notifications aim to make pedestrians aware of their actions. They inform about the person's impact on the good flow of the traffic and therefore create a sense of responsibility, or even guilt.



To build a good relationship with the user and personalise the service, notifications are sent informing the user about good performance of the pedestrian mode, which means safe and smooth street crossings.

An on-street advert at a bus stop reminding to have the pedestrian mode on

Future street-crossing

Enabling the pedestrian mode brings new ways of street crossing. The following images are exemplary situations of two different types of behaviours – crossing on designated pedestrian crossings (Figure 14) and jaywalking (Figure 15). Both schemes show the first step to be switching the pedestrian mode on, which can also be set to happen automatically. Yellow circles indicate key touchpoints and 'the new normals' related to the future street crossing with the pedestrian mode on you.

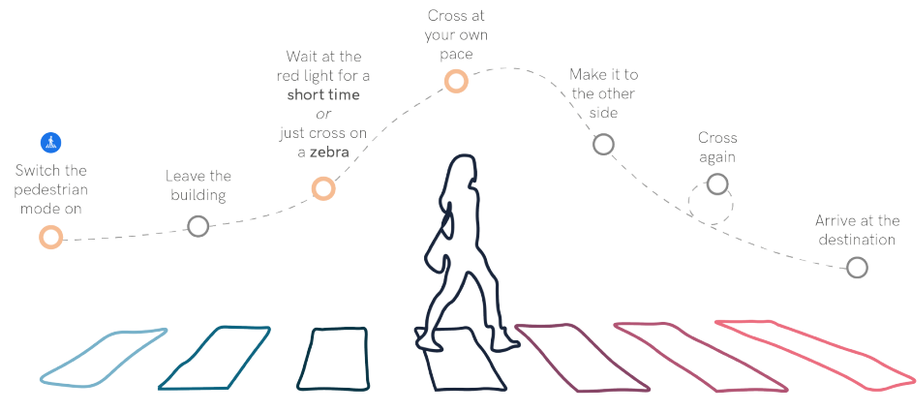


Figure 14: The future user journey of street-crossing with the pedestrian mode

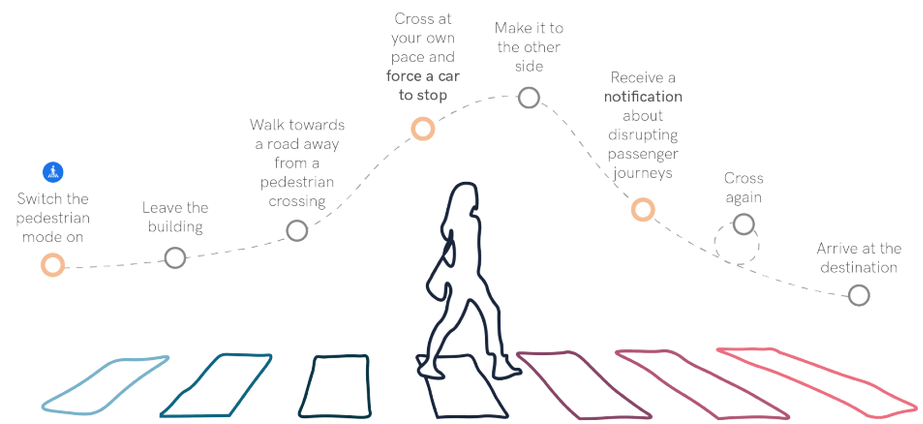


Figure 15: The future user journey of jaywalking with the pedestrian mode

Service blueprint

Customer journey	Become aware of self-driving car issues	Learn about pedestrian mode	Buy a device with pedestrian mode / system update	Adjust settings	Go out, use pedestrian mode	Get notified when disrupting cars repeatedly	See signs on the streets reminding to have pedestrian mode on	Follow your street crossing performance
Touchpoints	On-street & online advertisements	On-street & online advertisements	A device in a box/ current device alone	Personal device	Device, street crossings, autonomous vehicles	Personal device, notification	Street signs, streets	Personal device, settings page, notifications
What does Google do?	Informs people about possible risks, creates a need	Presents the pedestrian mode concept	Distributes the pedestrian mode, builds a relationship	Informs about data privacy and successful crossings, allows to control when the mode is on	Tracks user's data, assures device's communication with AVs and crossings	Stimulates people's sense of responsibility and empathy	Reminds people to use the feature	Builds a relationship with the user, keeps the user up to date with the operations of PM

Line of visibility

Line of visibility

PM - pedestrian mode

FAQ - 'and what if/about…?'

…someone loses their smartphone, forgets their smartwatch or runs out of battery?

More caution is advised, but the cars will still see the person. Pedestrian mode is an addition to already existing sensors in the car, ensures full visibility at all times and mitigates the car's algorithmic bias.

…regular cars? How does the existence of the pedestrian mode impact drivers?

The majority of regular cars will achieve certain level of autonomy. It means they can also have access to pedestrian mode data and communicate with pedestrians through their personal devices. Car drivers which cannot access the pedestrian data will have to pay extra attention on the streets and look out for possibly more jaywalkers than in 2019.

…the pedestrian mode does not stop people from jaywalking, even with the responsibility stimulation (notifications)?

This project proposes a service which puts pedestrian interest and safety first. It is possible that governments and autonomous taxi companies will strive to penalise jaywalkers in one way or another. However, the pedestrian mode works also for mitigating traffic, which might eventually lead to no disruptions for both the cars and pedestrians.

…regulations and law? If an accident happens, whose fault is it?

It is very possible, at least in the beginning of autonomous vehicle existence, that it will always be the car's fault when a pedestrian is harmed in an accident. On the other hand, assuming that the pedestrian mode assures 100% visibility and allows the car to adjust its actions to pedestrians, accidents with pedestrians should never happen.

…cyclists? Can they also use the pedestrian mode?

Anyone with the feature switched on will be visible to the AVs, regardless of their activity – standing, walking, running or cycling. Cars will be able to sense cyclists' presence in advance and adjust their speed accordingly.

Discussion

There will always be a mixture of cars on the street, like there is a mixture of old and new phones.

~ Digital Catapult

This dissertation emphasises the pedestrian point of view on the future of autonomous vehicles. By taking a human-centred approach – a major principle of design – it tries to understand and answer their needs. There are, however, other parties and stakeholders whose point of view is also crucial for the sustainable and successful development and delivery of the proposed solution.

Firstly, it is worth considering the reasons why certain organisations would, or should, engage in developing the pedestrian mode. Autonomous car manufacturers would greatly benefit in collaborating with tech companies which offer operating systems, i.e. iOS or Android, with the pedestrian mode feature. Through this, they could ensure both pedestrian and passenger safety by minimising accident rates. It can be argued that while this would strongly appeal to pedestrians, it would not be as attractive to passengers. They could claim that their journey in a car which supports the pedestrian mode is more likely to be disrupted by giving way to pedestrians. Although it is true that the pedestrian mode prioritises pedestrians, it also adjusts cars' behaviours to them which removes sudden braking and leads to smoothening of their journey. Therefore, driverless car companies which support the pedestrian mode feature might be considered both more pedestrian and passenger friendly.

Google was used as an excellent example of a company which develops both an operating systems and autonomous vehicles. Widespread Android personal devices and gadgets, which are likely to grow in number in the future, hold a great potential when it comes to positive societal impact, including the influence on transportation. This project suggests a way to use this potential and connect people with autonomous vehicles while providing them with visibility and safety. On the other hand, given the high level of unpredictability of human behaviours, pedestrian mode supports the AVs in making appropriate reactions. This bilateral opportunity would make Google, Apple or Microsoft the largest commercial beneficiaries of the pedestrian mode.

There are also profiters that maybe be detrimental to the success of the pedestrian mode. Insurance companies are already a subject of discussions over people's data privacy (e.g. using health information from mobile apps to insure health). The pedestrian mode feature would hold a significant amount of data regarding a person's lifestyle, locations and rates of jaywalking. Insurers might want to access this information to track behaviours of their clients and use it to their benefit. Moreover, it is widely speculated that in the future, cyberterrorism will play a major global role, with one of the targets being self-driving cars. Since the pedestrian mode connects AVs with people's devices, it might become both a great source of data and a point of access to the vehicles. It is not difficult to imagine the catastrophic consequences of these – redirecting the cars towards each other and causing mass accidents or even spying on individuals' daily routines.

It can be argued that the proposed service would make people even more reliant on technology than now and that it is a fragile source of personal data. Even more, the pedestrian mode could enhance fears in the society connected to self-driving cars. Given the street reminders to have the feature on and notifications stimulating responsibility, people might feel that it is in fact risky to be on street. Therefore, it is crucial to introduce the feature as a tool removing burdens from people rather than limiting their peace and freedom.

The service prototype presented for this project is aimed to apply to London pedestrians. The hectic, multi-cultural city poses a huge challenge for autonomous vehicles and the pedestrian mode aims to act as a supporting innovation. It is possible that the pedestrian mode would not be necessary in other cities where, for instance, jaywalking is unthinkable, drivers strictly obey the traffic rules and streets are easy to navigate. On the other hand, the service proposal requires access to technology and since it is not guaranteed in many places around the world, it would not be practical in those areas.

SWOT analysis

The following SWOT analysis shows the strenghts, weaknesses, opportunities and threats regarding the pedestrian mode feature.

Strengths

Increase of human behaviour predictability

Increase of pedestrian visibility to autonomous vehicles

Increased safety

Shorter wait time at the red light for pedestrians

Weaknesses

Not practical in places with limited access to technology

Not clear if lack of penalty system would work against jaywalking efficiently enough

Makes people more reliant on technology

Opportunities

Less accidents including pedestrians

Smooth traffic

More focus given to the feature's positive impact on disabled people

Threats

Data privacy violations

Cyber-terrorism

Data collected by the feature used for negative purposes by insurance companies

I had a rewarding opportunity to talk about my project at the Service Design Fringe Festival 2019 at the Barbican Centre. The general reaction to the topic helped me realise that, apart from being striking and exciting, the subject is also very distant to the audience. It shows that a lot has to be done in the near future in terms of rising people's awareness about the consequences of implementing self-driving cars on the society.

References

Adalid, M., Lant, K. and Luhman, G. (n.d.). *Laws and Ethics for Autonomous Cars*. [online] Futurism. Available at: https://futurism.com/images/laws-and-ethics-for-autonomous-cars [Accessed 9 Nov. 2019].

Aouf, R. (2018). *Lyft patents notification system for self-driving cars to communicate*. [online] Dezeen. Available at: https://www.dezeen.com/2018/12/14/lyft-patent-notification-system-self-driving-cars/ [Accessed 9 Nov. 2019].

Auger, J. (2013). Speculative design: crafting the speculation. *Digital Creativity*, 24(1), pp.11-35.

Bleecker, J. (2019). *On Design Fiction: Close, But No Cigar - Near Future Laboratory*. [online] Near Future Laboratory. Available at: http://blog.nearfuturelaboratory.com/2019/10/23/on-design-fiction-close-but-no-cigar/ [Accessed 15 Nov. 2019].

Brooks, R. (2017). *The Big Problem With Self-Driving Cars Is People*. [online] IEEE Spectrum: Technology, Engineering, and Science News. Available at: https://spectrum.ieee.org/transportation/self-driving/the-big-problem-with-selfdriving-cars-is-people [Accessed 9 Nov. 2019].

Chang, C., Toda, K., Sakamoto, D. and Igarashi, T. (2016). Eyes on a Car: an Interface Design for Communication between an Autonomous Car and a Pedestrian. pp.65-73.

Claburn, T. (2016). *Self-driving cars doomed to be bullied by pedestrians*. [online] Theregister.co.uk. Available at: https://www.theregister.co.uk/2016/10/27/selfdriving_cars_will_be_bullied_by_pedestrians/ [Accessed 10 Nov. 2019].

de Clercq, K., Dietrich, A., Núñez Velasco, J., de Winter, J. and Happee, R. (2019). External Human-Machine Interfaces on Automated Vehicles: Effects on Pedestrian Crossing Decisions. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 61(8), pp.1353-1370.

Hancock, T. and Bezold, C. (1994). Possible futures, preferable futures. *The Healthcare Forum*, pp.23-29.

Houser, K. (2019). *Self-driving cars may hit people with darker skin more often*. [online] Futurism. Available at: https://futurism.com/the-byte/biased-self-driving-cars-darker-skin [Accessed 9 Nov. 2019].

LeBeau, P. (2019). *Relax, experts say it's at least a decade before you can buy a self-driving vehicle*. [online] CNBC. Available at: https://www.cnbc.com/2019/07/29/experts-say-its-at-least-a-decade-before-you-can-buy-a-self-driving-car.html [Accessed 10 Nov. 2019].

Living Streets. (2019). *Walking Cities: Oxford Street*. [online] Available at: https://www.livingstreets.org.uk/get-involved/campaign-with-us/walking-cities/walking-cities-oxford-street [Accessed 10 Nov. 2019].

Ma, A. (2018). *China has started ranking citizens with a creepy 'social credit' system — here's what you can do wrong, and the embarrassing, demeaning ways they can punish you*. [online] Business Insider. Available at: https://www.businessinsider.com/china-social-credit-system-punishments-and-rewards-explained-2018-4?r=US&IR=T [Accessed 12 Nov. 2019].

Maxmen, A. (2018). *Self-driving car dilemmas reveal that moral choices are not universal*. [online] Nature.com. Available at: https://www.nature.com/articles/d41586-018-07135-0 [Accessed 9 Nov. 2019].

Millard-Ball, A. (2016). Pedestrians, Autonomous Vehicles, and Cities. *Journal of Planning Education and Research*, 38(1), pp.6-12.

Moral Machine. (2016). *Moral Machine*. [online] Available at: http://moralmachine.mit.edu/ [Accessed 9 Nov. 2019].

Nicholas, L. (2013). *Futurology: shining a bright, broad beam of light into the darkness | Lydia Nicholas*. [online] the Guardian. Available at: https://www.theguardian.com/science/political-science/2013/may/03/science-policy [Accessed 14 Nov. 2019].

Rasouli, A. and Tsotsos, J. (2019). Autonomous Vehicles That Interact With Pedestrians: A Survey of Theory and Practice. *IEEE Transactions on Intelligent Transportation Systems*, pp.1-18.

van Gaalen, S. (2016). *Theory of Change and the Futures Cone. – Structure & Narrative*. [online] Sjef.nu. Available at: https://sjef.nu/theory-of-change-and-the-futures-cone/ [Accessed 14 Nov. 2019].

Voros, J. (2003). A generic foresight process framework. *Foresight*, 5(3), pp.10-21.

Walmsley, J. (2018). *What Does The Future Hold For Ride-Hailing? Here Are 7 Expert Predictions*. [online] Forbes.com. Available at: https://www.forbes.com/sites/juliewalmsley/2018/12/09/what-does-the-future-hold-for-ride-hailing-here-are-7-expert-predictions/#2947a2c4b257 [Accessed 10 Nov. 2019].

Bibliography

Ai.google. (2019). *Tools for everyone*. [online] Available at: https://ai.google/tools/ [Accessed 21 Nov. 2019].

Aperture (2018). *Artificial Intelligence: Mankind's Last Invention*. [video] Available at: https://www.youtube.com/watch?v=Pls_q2aQzHg [Accessed 21 Nov. 2019].

Bajorek, J. (2019). *Voice Recognition Still Has Significant Race and Gender Biases*. [online] Harvard Business Review. Available at: https://hbr.org/2019/05/voice-recognition-still-has-significant-race-and-gender-biases [Accessed 21 Nov. 2019].

Bedigian, L. (2018). *Autonomous Vehicles and the Subtleties of Human Interaction*. [online] Smart Mobility Hub. Available at: https://www.smart-mobility-hub.com/autonomous-vehicles-and-the-subtleties-of-human-interaction/ [Accessed 19 Nov. 2019].

Buckley, C. and Mozur, P. (2019). *How China Uses High-Tech Surveillance to Subdue Minorities*. [online] Nytimes.com. Available at: https://www.nytimes.com/2019/05/22/world/asia/china-surveillance-xinjiang.html [Accessed 21 Nov. 2019].

CBS News (2019). *"We're heading towards hell": Expert shares concerns with self-driving cars*. [video] Available at: https://www.cbsnews.com/news/self-driving-cars-were-heading-towards-hell-expert-shares-concerns-with-autonomous-vehicles-2019-08-31/ [Accessed 19 Nov. 2019].

Digital Ethics Lab. (2017). *ESIAI: Ethical and Social Implications of AI*. [online] Available at: https://digitalethicslab.oii.ox.ac.uk/esiai-ethical-and-social-implications-of-ai/ [Accessed 21 Nov. 2019].

Eliseev, A. (2019). *Why London's streets are a total nightmare for self-driving cars*. [online] Wired.co.uk. Available at: https://www.wired.co.uk/article/driverless-cars-london-challenges-ai [Accessed 19 Nov. 2019].

Ethicstoolkit.ai. (2019). *Ethics & Algorithms Toolkit (beta)*. [online] Available at: https://ethicstoolkit.ai/ [Accessed 21 Nov. 2019].

Growth Tribe (2018). *How to Prepare Data for Machine Learning and A.I*. [video] Available at: https://www.youtube.com/watch?v=TK-2189UcKk [Accessed 21 Nov. 2019].

Gullo, K. (2019). *Meet the Bay Area Women in Tech Fighting Bias in AI*. [online] Seismic Sisters. Available at: https://www.seismicsisters.com/newsletter/women-in-tech-fighting-bias-in-ai [Accessed 21 Nov. 2019].

Hasegawa, A. (2019). *Ai Hasegawa - Alt-Bias Gun*. [online] Aihasegawa.info. Available at: https://aihasegawa.info/alt-bias-gun [Accessed 21 Nov. 2019].

Hicks, M. and Fitzsimmons, M. (2019). *Self-driving cars: your complete guide*. [online] TechRadar. Available at: https://www.techradar.com/uk/news/self-driving-cars [Accessed 18 Nov. 2019].

Hulse, L., Xie, H. and Galea, E. (2018). Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Safety Science*, 102, pp.1-13.

Holley, P. (2018). *How do you get people to trust autonomous vehicles? This company is giving them 'virtual eyes.'*. [online] The Washington Post. Available at: https://www.washingtonpost.com/technology/2018/08/29/how-do-you-get-people-trust-autonomous-vehicles-this-company-is-giving-them-virtual-eyes/?noredirect=on [Accessed 19 Nov. 2019].

IBM. (2018). *Bias in AI: How we Build Fair AI Systems and Less-Biased Humans*. [online] Available at: https://www.ibm.com/blogs/policy/bias-in-ai/ [Accessed 21 Nov. 2019].

Isaac, L. (n.d.). *Driving Towards Driverless Cars*. [online] Driving Towards Driverless Cars. Available at: https://drivingtowardsdriverless.com/ [Accessed 18 Nov. 2019].

Jafary, B., Rabiei, E., Diaconeasa, M., Masoomi, H., Fiondella, L. and Mosleh, A. (2018). A Survey on Autonomous Vehicles Interactions with Human and other Vehicles.

Jing, M. (2017). *Facial recognition technology becoming part of everyday life in China*. [online] South China Morning Post. Available at: https://www.scmp.com/tech/social-gadgets/article/2132465/travel-and-retail-banking-chinas-facial-recognition-systems-are [Accessed 21 Nov. 2019].

Kahn, J. (2018). *Why Not Just Retrain Pedestrians to Make Self-Driving Vehicles Safer?*. [online] Insurance Journal. Available at: https://www.insurancejournal.com/news/national/2018/08/17/498414.htm [Accessed 18 Nov. 2019].

Kairos. (2019). *Kairos: Serving Businesses with Face Recognition*. [online] Available at: https://www.kairos.com/ [Accessed 21 Nov. 2019].

Lee, D. (2019). *San Francisco bans facial recognition in US first*. [online] BBC News. Available at: https://www.bbc.co.uk/news/technology-48276660 [Accessed 21 Nov. 2019].

Lee, T. (2018). *Pedestrians are a hard problem for self-driving cars—here's one solution*. [online] Ars Technica. Available at: https://arstechnica.com/cars/2018/07/new-software-gives-self-driving-cars-intuitive-understanding-of-pedestrians/ [Accessed 18 Nov. 2019].

Lester, C. (2019). *A Study on Driverless-Car Ethics Offers a Troubling Look Into Our Values*. [online] The New Yorker. Available at: https://www.newyorker.com/science/elements/a-study-on-driverless-car-ethics-offers-a-troubling-look-into-our-values# [Accessed 18 Nov. 2019].

Martin, N. (2018). *Are AI Hiring Programs Eliminating Bias Or Making It Worse?*. [online] Forbes.com. Available at: https://www.forbes.com/sites/nicolemartin1/2018/12/13/are-ai-hiring-programs-eliminating-bias-or-making-it-worse/#a2de2522b8f4 [Accessed 21 Nov. 2019].

Marx, P. (2018). *Self-Driving Cars Are Not the Future*. [online] Medium. Available at: https://medium.com/s/story/the-future-of-mobility-belongs-to-people-not-self-driving-cars-625c05b29692 [Accessed 18 Nov. 2019].

Maurer, M., Gerdes, J., Lenz, B. and Winner, H. (2015). *Autonomous Driving. Technical, Legal and Social Aspects*. Springer Open.

McGrath, M. (2019). *Beginner's Guide to Autonomous Vehicles (Self-Driving Cars): Answers to Most Frequently Asked Questions (FAQs) about Autonomous Vehicles*.

Michigan Engineering (2019). *Predicting pedestrian movement in 3D for driverless cars*. [video] Available at: https://www.youtube.com/watch?v=YIB8IALSwmE [Accessed 19 Nov. 2019].

Miller C, Coldicutt R. (2019) *People, Power and Technology: The Tech Workers' View*. London: Doteveryone. Available at: https://doteveryone.org.uk/report/workersview

O'Brien, M. (2019). *MIT Researcher Exposing Bias in Facial Recognition Tech Triggers Amazon's Wrath*. [online] Insurance Journal. Available at: https://www.insurancejournal.com/news/national/2019/04/08/523153.htm [Accessed 21 Nov. 2019].

Samuel, S. (2019). *Some AI just shouldn't exist*. [online] Vox. Available at: https://www.vox.com/future-perfect/2019/4/19/18412674/ai-bias-facial-recognition-black-gay-transgender [Accessed 21 Nov. 2019].

Shankland, S. (2019). *Facial recognition that only works well with men is terrible business idea, MIT researcher says*. [online] CNET. Available at: https://www.cnet.com/news/facial-recognition-errors-are-bad-for-business-most-of-us-arent-white-men/ [Accessed 21 Nov. 2019].

Shutko, J. (2017). *How Self-Driving Cars Could Communicate with You in the Future*. [online] Ford Social. Available at: https://social.ford.com/en_US/story/ford-community/move-freely/how-self-driving-cars-could-communicate-with-you-in-the-future.html [Accessed 19 Nov. 2019].

Singh, S. (2015). Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey.

TED (2019). *How to keep human bias out of AI | Kriti Sharma*. [video] Available at: https://www.youtube.com/watch?v=BRRNeBKwvNM [Accessed 21 Nov. 2019].

Thehive.ai. (2019). *The Complete Deep-Learning Toolkit | Hive*. [online] Available at: https://thehive.ai/ [Accessed 21 Nov. 2019].

Verger, R. (2019). *How Self-Driving Cars Can Predict the Way Pedestrians Move*. [online] Popsci.com. Available at: https://www.popsci.com/pedestrian-prediction-self-driving-cars/ [Accessed 19 Nov. 2019].

Vincent, J. (2019). *China's latest use for facial recognition: identifying pandas*. [online] The Verge. Available at: https://www.theverge.com/2019/5/21/18633787/facial-recognition-app-panda-china-chengdu-conservation [Accessed 21 Nov. 2019].

Vox (2015). *Color film was built for white people. Here's what it did to dark skin.*. [image] Available at: https://www.youtube.com/watch?v=d16LNHIEJzs [Accessed 21 Nov. 2019].

Wakelin, N. (2017). *How Will Autonomous Cars Communicate with People on the Street?*. [online] BestRide. Available at: http://bestride.com/news/technology/how-will-autonomous-cars-communicate-with-people-on-the-street [Accessed 19 Nov. 2019].

Wallis, E. (2019). *Green light for robot cars*. [online] Hiscox London Market. Available at: https://www.hiscoxlondonmarket.com/magazine/issue18/green-light-robot-cars?fbclid=IwAR2b9xNotDnyIJDLMF1x-9C2LteztqIUYoVq4IOivlkF2HQLdDKVewJI45RU [Accessed 19 Nov. 2019].

Winkless, L. (n.d.). *Reading The Road: How Will Driverless Cars Talk To Pedestrians?*. [online] SciPol.org. Available at: https://scipol.org/content/reading-road-how-will-driverless-cars-talk-pedestrians [Accessed 19 Nov. 2019].

Yan, M. (2019). *Facial recognition is almost perfectly accurate — here's why that could be a problem*. [online] Business Insider. Available at: https://www.businessinsider.com/facial-recognition-technology-regulation-creepy-future-2019-4?r=US&IR=T [Accessed 21 Nov. 2019].

Appendix

Online survey questions

1. How familiar are you with the self-driving cars concept?

   Not at all familiar, not so familiar, somewhat familiar, very familiar, extremely familiar.

2. What is your attitude towards implementation of self-driving cars in the upcoming years?

   Very worried – Neutral/Don't care – Very optimistic

3. Would you be willing to adapt new behaviours for crossing the street in order to make the interaction between you and a self-driving car safer and easier (e.g. raise your hand to notify the car of your intention to cross).

   Yes/No

4. Do you think self-driving cars should adjust their behaviours to pedestrians or it's the pedestrians who should adjust their behaviours to self-driving cars?

   Self-driving cars should adjust, pedestrians should adjust, a bit of both

5. Would you like to be informed about/educated about the behavioural 'DOs and DONTs' around self-driving cars?

   Yes/No

6. If the self-driving cars were likely to hit and harm your demographic group (i.e. your ethnic or age group) more than other groups, how would knowing this affect you? (e.g. avoid jaywalking, avoid the street, scared, etc.)

   [textbox]

7. What general impact, in your opinion, will self-driving cars have on pedestrians?

   Very negative – No impact – Very positive

8. And why do you think so?

   [textbox]

9. Gender

10. Age