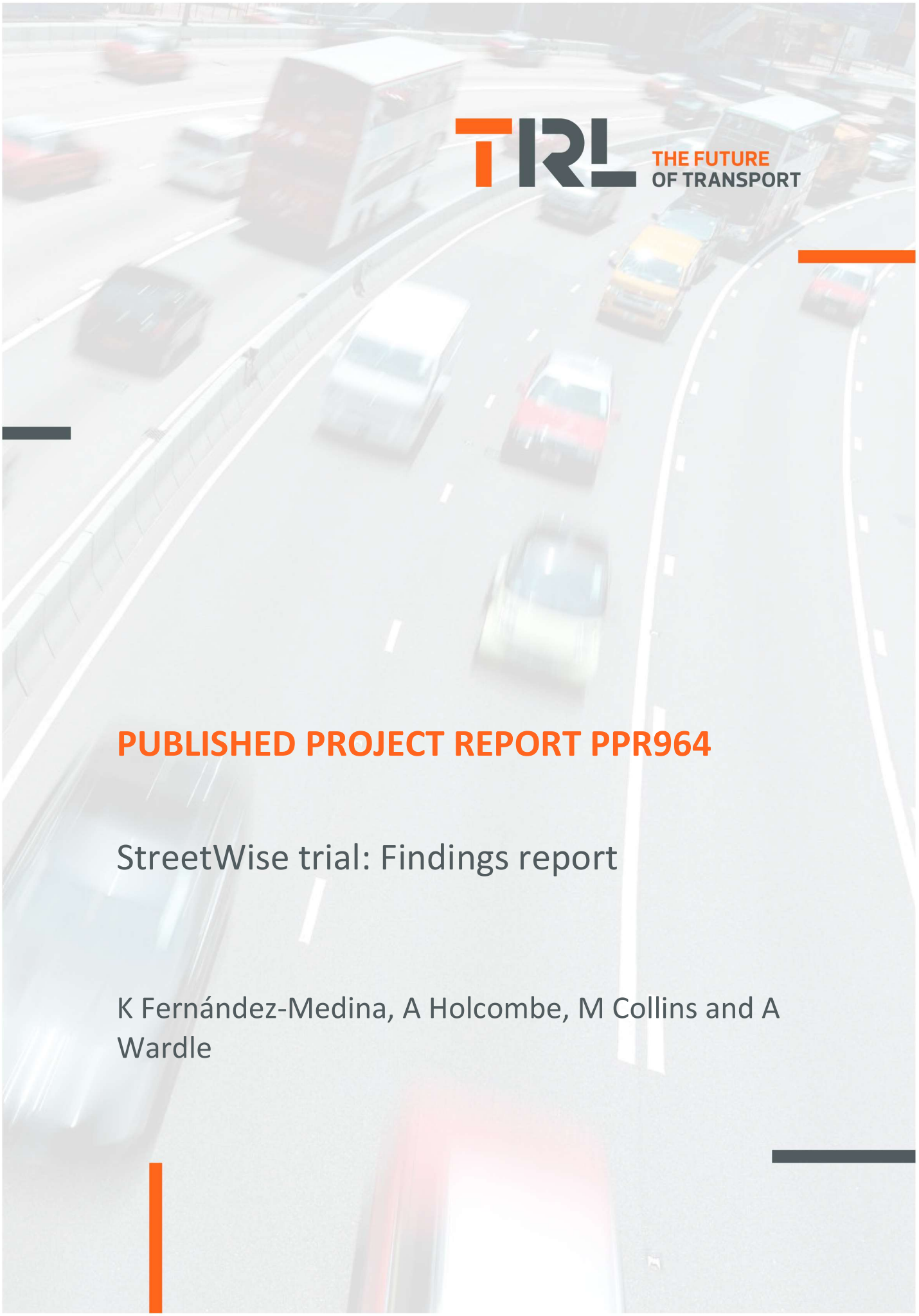

THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR964

StreetWise trial: Findings report

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1 Executive summary

The StreetWise project explored the commuting opportunities provided by self-driving vehicle technology. Led by Five (a company that specialises in self-driving technology), 110 participants experienced a 13-mile return trip in a self-driving vehicle along busy urban roads. These demonstration drives along a commuter route in London formed one of the most complex automated vehicle trials completed in public in Europe so far. Built into the trial was a substantial research study to understand the views of those who experienced a journey in one of these self-driving vehicles, the results of which are the focus of this report. The key aim of this research was to gain credible and real-world insights on factors that might affect the uptake of automated vehicle mobility services. The trial sought to present self-driving vehicles as complementary to existing modes of sustainable and/or public transport.

Participant ratings of the self-driving experience

Five's self-driving experience received a positive overall rating from almost all participants (96%) and it exceeded the prior expectations of 86% of the sample. Safety was first and foremost when delivering the trial, which was governed by a comprehensive safety case. The priority given to safety appeared to be recognised by the vast majority of participants, as 92% reported feeling safe during their self-driving experience. Participants' reasons for rating safety so highly included experiencing Five's self-driving vehicles handling complex road situations (e.g. roundabouts) as well as the presence of Five's safety drivers and their cautious supervision of the automated experience. In addition, the post-experience questionnaire showed that most participants (81%) generally reported high trust in the automated driving system that they experienced. These ratings were provided at the end of the self-driving experience but remained consistent with ratings also taken in real-time during the self-driving experience. These high ratings are noteworthy given the highly complex European public road environment in which the self-driving vehicles had to operate.

Willingness to pay and use

After experiencing Five's self-driving vehicles, participants reported that they would be willing to pay on average £5.50 for a shared automated vehicle (rising to an average of £10.90 if the vehicle was private hire) for a similar commuting trip of about 6.5 miles (lasting around 20 minutes). These prices fell between the cheaper option of a bus for the same journey (£1.50) and the more expensive London taxi or Uber options (£17 and £15, respectively).

Based on this experience, there was a preference for commuter services powered by similar self-driving technology in place of and/or in addition to other modes of transport. Participants were most likely to use company cars, taxis and buses less if such self-driving technology was made more widely available as a transport mode. The data also suggested it would impact private vehicle use, with 53% of participants claiming that they would use their own vehicles less often if automated transport services were available. Cycling and walking were the modes least likely to be affected by the availability of self-driving vehicles, which is a positive indicator for towns and cities that are targeting cleaner air and less traffic.

This willingness for modal shift towards self-driving services was more likely for specific journey purposes, such as daily commuting, business travel or a range of leisure activities (e.g. a trip to a restaurant in the evening).

Areas for future development

There are factors that need to be considered for future development of self-driving vehicles and therefore increasing uptake, including optimisation of passenger ride comfort (in this trial, this was operationally defined as the perceived smoothness of the journey). This was the lowest-rated attribute throughout the experience (although still rated as 'smooth' by 67% of the sample) and also the attribute with the highest level of variability in responses. This was primarily due to prioritising rider safety over comfort when operating in a complex urban road environment.

From a research perspective, the qualitative data showed that participants had difficulty separating the concepts of safety, security and trust, and articulating distinct definitions for each. The sample described what came to mind when each construct was mentioned. For 'safety' examples included family, children and environment; for 'security' examples included predictability, home and protection; and for 'trust' examples were expectation, experience and authority. Definitions for safety and security tended to overlap considerably, whereas safety and trust were reported to be more distinct from each other. This research enhances our understanding of how these constructs are similar and how they differ. This insight will help future stakeholders to design research and self-driving services that better meet the needs of consumers, address their concerns, assuage their fears and offer the reassurances they desire.

Participants also offered suggestions as to how the industry can present self-driving vehicles to the public in order to improve uptake and refine the potential services on offer. Suggested areas of focus included availability (especially in areas with poor or irregular public transport alternatives), convenience (exceeding that of private car journeys by offering time to focus on activities other than driving) and mobility (such as providing services to those who are otherwise unable to drive). This input from potential users has helped to outline insightful future steps for the vehicle automation industry and associated stakeholders and implies a degree of enthusiasm for the technology.

This project has demonstrated that existing vehicle automation could provide a safe, trustworthy and competent commuter mobility solution in urban areas. The trial generated encouraging data to suggest that self-driving vehicles could play an important role in an integrated, sustainable transport network that might ultimately encourage people to move away from using private vehicles for such journeys. A key part of the challenge will be to understand how best to open a dialogue with the public on key matters such as the safety, security and trust that are associated with vehicle automation.

2 Introduction

Automated vehicle (AV) technology continues to grow in capability and complexity. Although many trials around the world have demonstrated this technology within the context of city centres and short (last-mile-type) journeys, there is still much to understand in terms of the more sustainable applications of vehicle automation, particularly if it is to become a viable commuter transport option.

Understanding how possible future users engage with self-driving vehicles, how any new transport option may fit in with existing transport that people use and people's future transport needs, requires direct exposure to such technologies. Only then can we assess the true benefits and unintended consequences of such technologies. This has been demonstrated in other research including the GATEway project where participants of a self-driving vehicle trial in London highlighted how physical trials of AVs could help build trust in this technology (Fernández-Medina *et al.*, 2018).

September 2017 saw the launch of the 2.5 year-long StreetWise project. Led by Five, a self-driving technology company, this project had multiple workstreams including an opportunity for a 'commuter trial' to allow people to experience self-driving technology on public roads. The trial provided participants with a direct experience of a self-driving vehicle (prototype SAE L4). The self-driving vehicles used for the trial were adapted by Five; these were Ford Mondeo hybrid vehicles fitted with an array of sensors and powered by Five's self-driving software (for more information on the vehicles used, see Fernández-Medina *et al.*, 2020). Built into the trial was a substantial research study to understand the views of those who experienced a journey in one of these self-driving vehicles, the results of which are the focus of this report. The research sought to go beyond standard measures of journey experience, in order to assess how people define and think about common constructs often used within the remit of vehicle automation: safety, security and trust. Understanding the basics of how and what we measure when studying the impact and uptake of vehicle automation form important building blocks for future research and development.

TRL conducted the research element of the Five-led StreetWise trial.

2.1 Background to the StreetWise project

The StreetWise project aimed to develop and demonstrate the technology, safety validation methods, insurance and service models required to deliver a self-driving shared mobility solution, targeted at replacing the personal urban commuter car. The project was led by Five, a UK-based company whose expertise lies in the vehicle engineering, machine learning, artificial intelligence and safety fields associated with the development and deployment of self-driving vehicles. Other consortium partners included:

- TRL
- Direct Line Group (DLG)
- Oxford University Torr Vision Group
- McLaren Applied Technologies

- Warwick Manufacturing Group
- Claytex
- Transport for London

Funding for the project came in part from the Industrial Strategy Challenge Fund and was match funded by some of the partners. It was delivered via Innovate UK.

Safety is fundamental in the domain of vehicle automation and, in line with the Department for Transport's Code of Practice and Five's own protocols, a Safety Case was developed by TRL. This ensured the necessary legal requirements were met to conduct testing on UK roads and secure insurance for the trial. The Safety Case outlined all the requirements that were satisfied in order for the public trial to take place. An abridged version was published to provide a publicly available overview of the trial and its approach to risk management, to give assurance that the trial would be conducted safely and risks appropriately managed. Although this abridged Safety Case applied specifically to public road trial in London, Five adhere to the same principles when testing automated vehicles elsewhere in the UK.

This research project evolved through multiple work packages, including desk-based planning of the trial and research materials by TRL and Five, as well as Five's thorough testing of the self-driving technology in simulation and on private tracks prior to phased public road tests. The work from all three project streams culminated in this trial, which allowed an invited group of participants to experience the technology themselves on public roads, amongst other human-driven traffic.

2.2 Trial aims

The key aim of this research was to gain credible and real-world insights on different aspects that could impact the uptake of an AV ridesharing service. The aim was to present self-driving vehicles as complementary – not competitive – to existing modes of sustainable and public transport.

It was intended that these real-world insights could then be used to:

- Increase understanding of how future, shared, self-driven services can meet end-user needs, such as supporting more seamless and efficient multimodal journeys, as well as reducing single occupancy vehicle journeys
- Understand how effective, capable and acceptable current self-driving technology is to a sample of potential end-users, based on a real-world experience
- Direct future research that increasingly focuses on opportunities and challenges to achieving uptake of AVs and new services
- Understand what language is appropriate and effective when designing questionnaires to understand behaviour within this new context

2.3 What makes this work different?

The research TRL has undertaken as part of the StreetWise project differs from prior research in several important ways.

It provides:

- A focus on the demonstration of self-driving technology within a clear-cut use case (i.e. demonstrating a shared automated vehicle service concept with London commuters in mind, on a route that might be used realistically for commuting purposes)
- Real-world insights from a road-ready self-driving vehicle interacting with other road users in live traffic situations on public roads
- Real-world participant experience of AVs within a complex, urban public road environment tackling a variety of road features that the invited trial participants would not have experienced in a self-driving vehicle before (e.g. roundabouts, junctions, signalised crossings, busy and mixed traffic)

2.4 This report

This report contains the key quantitative and qualitative findings from the trial. For more information about the method and procedure, as well as detailed information about the analysis and sample characteristics, please refer to the StreetWise trial: Technical report (Fernández-Medina *et al.*, 2020).

3 Method

The research undertaken as part of this project was designed to be modular, with the work divided into two main stages (Figure 1).

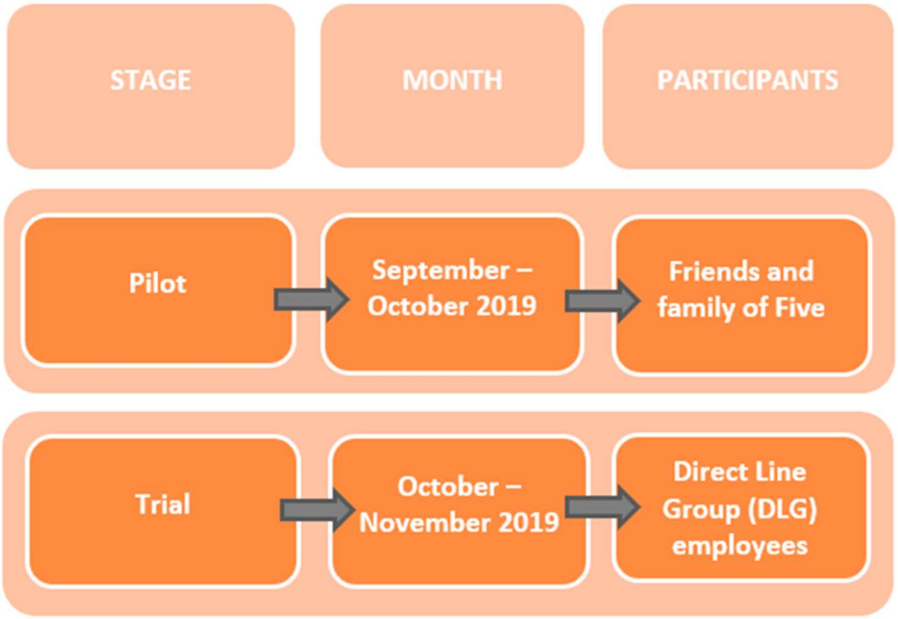

Figure 1: Trial phases

The pilot phase allowed the project team to assess the feasibility of a larger scale trial, as well as to test the effectiveness of the research tools developed. For this reason, the invited sample was drawn from friends or family of Five's employees. This helped the team to better manage the disappointment and disruption associated with any last-moment changes to trial schedules, which were anticipated during this pilot stage. It also helped to preserve the confidentiality of Five's technology, which was a further consideration given the highly competitive market for vehicle automation.

Once the pilot phase was completed successfully, the full trial (with the DLG sample) was started. Again, a decision was made to invite a specific group of people (this time employees of Direct Line Group, Five's insurance partner and a StreetWise consortium member). It should be noted that DLG employees were invited from parts of DLG's business that were not involved directly with Five or the StreetWise project. As with the pilot phase, there were essential procedures to help preserve Five's intellectual property and confidentiality; these were simpler to administer with employees of an existing consortium partner. A final compelling reason for sampling from this specific population group was the preservation of a use case: by inviting DLG employees to experience a journey between their office location and a nearby major public transport hub (along a major route used by private car commuters) was expected to enable the majority to envisage how the technology might affect all or part of the daily commute.

3.1 Participants

The study had 110 participants in total, 37 of which were from the pilot phase (friends and family of Five), and 73 in the trial phase (DLG employees). For full information on the sampling method and recruitment techniques used for both the pilot and trial phases of the work, refer to the Technical Report (Fernández-Medina *et al.*, 2020). Figure 2[1] provides insights into the characteristics of the sample that relate to the rest of the findings presented in this report. These characteristics were collected via questions in the pre-experience questionnaire. For more information about the trial participants, including vehicle ownership and most common fuel type, refer to the Technical Report (Fernández-Medina *et al.*, 2020). The Technical report also provides a breakdown of demographics and commuting, and travel patterns stated before participation in the trial.

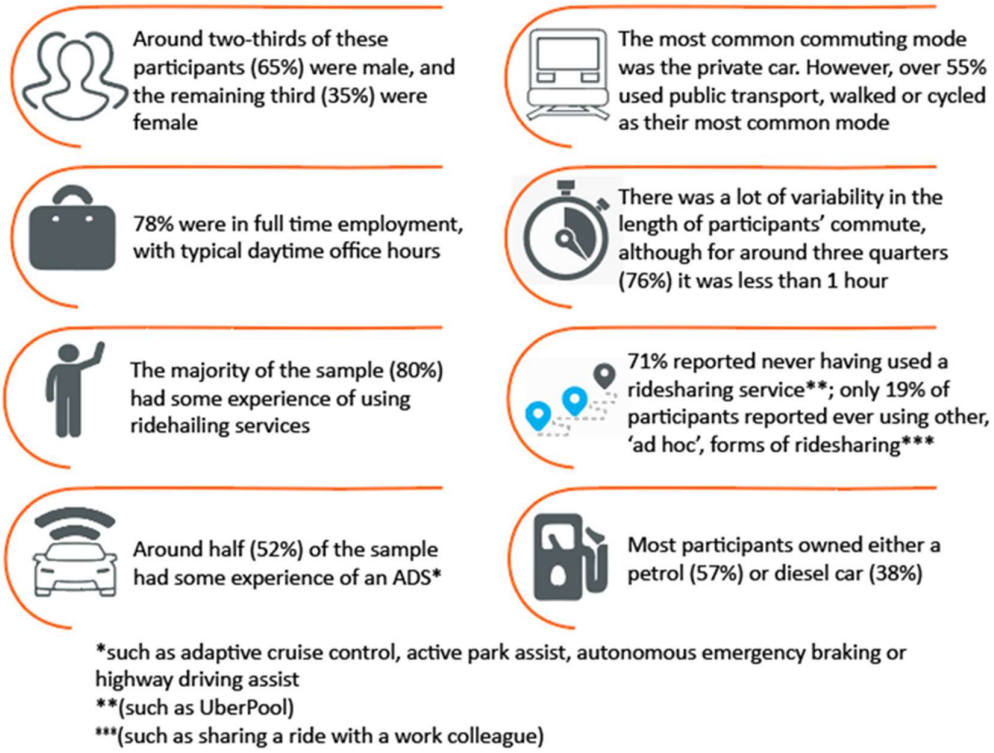

Figure 2: Statistics relating to the sample

[1] Note that ridesharing and ridehailing mentioned in the sample infographic, although used interchangeably, are not equivalent. The SAE Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies (SAE, 2018) defines 'ridesharing' as "the formal or informal sharing of rides between drivers and passengers with similar origin-destination pairings" (p. 8); ridehailing (or ridesourcing) is defined within the same document as "a for-hire vehicle service with one paid driver and one paying passenger" (p.12). The method used in the present research applied these definitions for questionnaire development and reporting.

3.2 Route

The route selected was almost 14 miles long and was a round trip starting either in Croydon or Bromley. Traffic depending, the trip took between 45 minutes to an hour.

The route included self-driving operation for the following route features:

- Urban streets (20-30 mph)
- Urban dual carriageway (30 mph)
- Shared tramways
- Roundabouts (range of sizes, from 3 to 5 exits)
- T-junctions
- Signalised junctions and crossroads
- Signalised pedestrian crossings

3.3 Procedure

The trial ran on weekdays (Tuesdays and Wednesdays), from 09:30 (first slot) to 15:30 finish (last slot being at 1:30). Despite it being a longer in-car experience compared to other CAV trials, this allowed passengers to take in many complex elements of the route, and more time to settle into a journey, as it would be imagined they would if they used it regularly. Figure 3 shows what trial participants experienced on trial days:

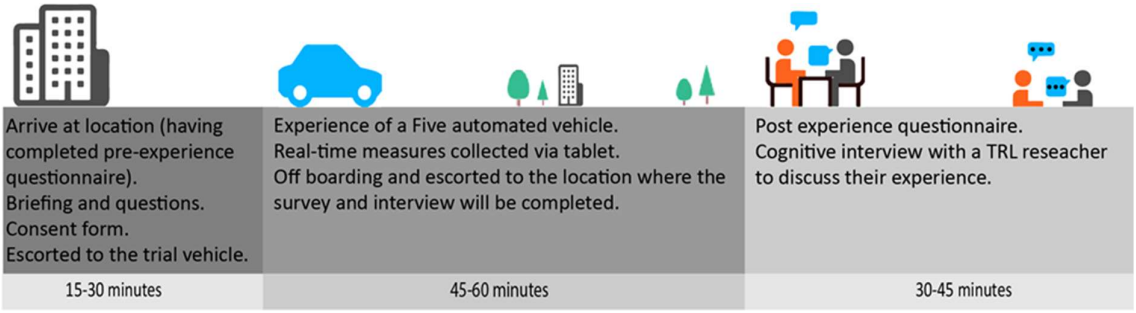

Figure 3: Procedure of trial participant experience

Not all participants experienced a cognitive interview. This part of the trial was completely optional and also depended on the availability of the participants and researchers on the day of testing. All participants completed the quantitative measures, as described below.

3.4 Measures

The research employed a number of measures to assess participant's demographics and current travel patterns, their in-vehicle experience and perceptions of the future. More detail

into these collection methods is provided in Figure 4 and below, and the full versions of each are provided in the technical report (Fernández-Medina *et al.*, 2020).

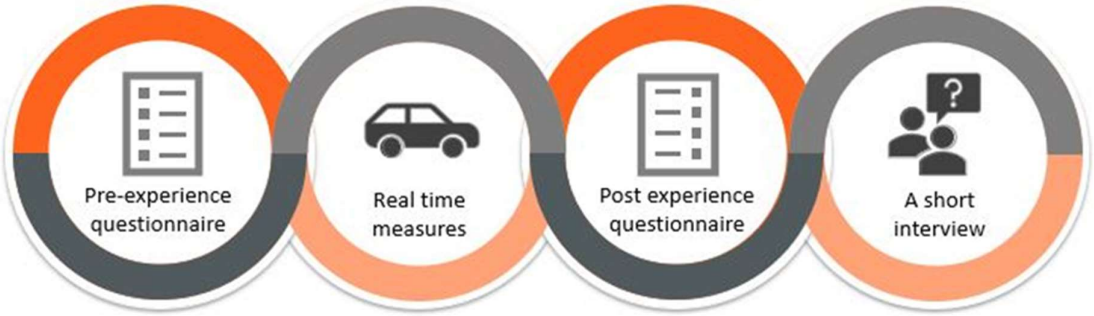

Figure 4: Collection methods used throughout the StreetWise trial

- A pre-experience questionnaire: Participants completed these before their journey in the trial vehicle, which provided mainly quantitative results.
- 'Real time' measures: A questionnaire with the same questions repeated at ten regular intervals on a tablet during the journey (five survey time points for each direction of the journey, prompted by the Five test engineer in the vehicle). This gathered perceptual feedback during the journey that could be used to measure changes in response based on the complexity of the route and how well each section was managed by Five's Automated Driving System (ADS). The questions measured perceptions of safety, smoothness, trust and overall experience.
- A post-experience questionnaire: This was completed by participants immediately after the self-driving experience, with mainly quantitative results, relating to their experience, expectations, concerns and possible future service models.
- A short qualitative interview: This was a cognitive style interview that was conducted immediately after the post-experience questionnaire. It measured trial experience and perceptions of the technology as well as participants' definitions of safety, security and trust.

Collectively, these measures enabled the team to assess various aspects of the participant experience and measure factors that have been found to relate to perceptions of self-driving vehicles in prior research.

4 Findings

4.1 Limitations of the sample

The invitational nature of participant sampling (and the self-selection of participants for the trial) counts as a limitation of the study; in this respect, the sample is not necessarily representative of the general population. All participants had reported that this was their first experience in a fully self-driving vehicle. Although several had the potential to be familiar with the self-driving industry, and may have held a sympathetic bias towards it, there were still varied responses to the questionnaires and interviews as well as variability in the demographics as displayed in Figure 2. Moreover, the DLG sample also had the benefit of being able to view their self-driving experience within the specific context of their daily commute.

4.2 Thematic areas

Various aspects of the journey experience were explored as part of the analysis of the trial, which can be categorised in research themes. The 'real time' measures produced some interesting findings as part of these themes, as do the outputs from other areas.

4.3 Journey experience

During and after the self-driving experience, participants were asked to rate their experience on a visual analogue scale (VAS)[2]; higher scores indicate a more positive response. The following subsections describe the range of participant responses.

4.3.1 Rider safety ratings (overall) for the self-driving experience

Figure 5 shows the distribution of overall safety ratings from participants at the end of their self-driving experiences (mean safety rating was 77 out of 100). It shows that the vast majority of participants (92%) had a generally positive impression of safety from their Five self-driving experience (indicated by a rating above '50' on a response scale of 0 to 100). Indeed, half of participants (50%) gave an overall safety rating at the top end of the rating scale (a rating of 81-100), which can be interpreted as perceiving the Five experience as feeling 'very safe'. A further 38% of participants gave safety ratings of 61-80, which could be interpreted as feeling 'moderately safe'.

[2] The VAS anchor points ranged from 'not at all' to 'very' for safety and smoothness; "no trust at all" to "complete trust" for trust; and, for the overall self-driving experience, 'negative' to 'positive'.

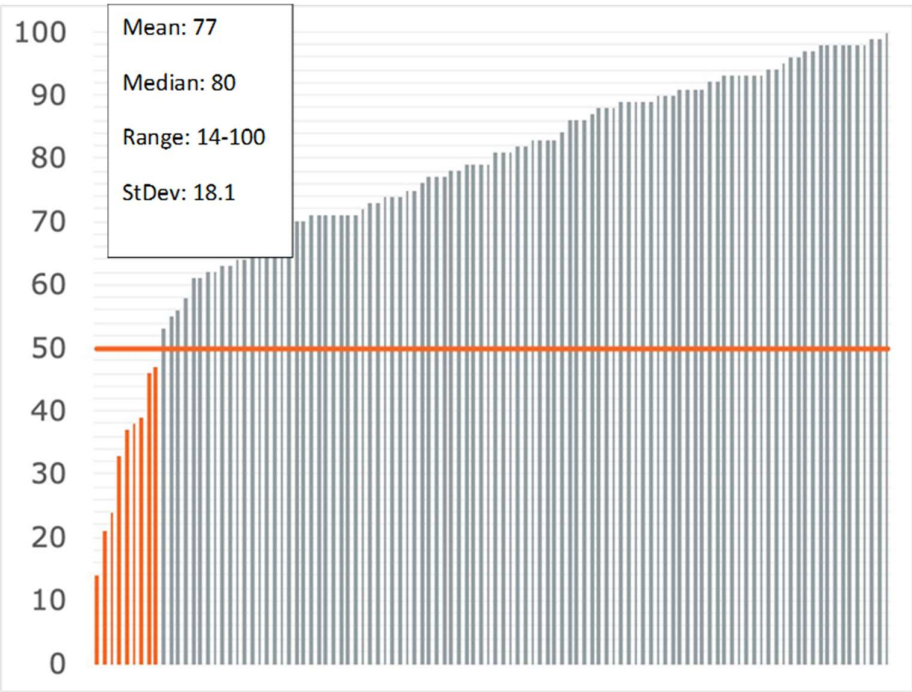

Figure 5: Distribution of individual participant responses for overall safety rating ('0' not at all safe – '100' very safe)

Riders were invited to give the three most important reasons for their safety rating in the form of open text responses. When Five's ADS operated as expected (and within the prescribed Operational Design Domain - ODD), participants were impressed with its driving 'skills' (Figure 6). Particular praise was given to how Five's ADS maintained a safe headway to vehicles in front (a recognition of how complex it is to manage headway in urban traffic, which is typically outside the ODD for manufacturer versions of adaptive cruise control systems). Similarly, the way in which Five's ADS handled roundabouts was also praised, not only for being 'cautious' but also for managing roundabouts 'better than a human' in some examples.

It is clear that when Five's self-driving vehicles were presented with urban traffic situations that are considered relatively complex for human drivers (such as roundabouts and unpredictable urban traffic), participants recognised how such manoeuvres had been designed to prioritise safety.

Of course, given that Five's ADS was subject to continuous development and testing at the time of the StreetWise trial, participants commonly experienced situations where the driving situation was outside the prescribed ODD and therefore outside the safety case. In such situations, the safety driver took manual control until conditions returned to being within the ODD. Such situations also seemed to contribute to high safety ratings. For example, several participants commented on the 'responsiveness' of Five's safety drivers when it came to challenging traffic situations that were outside the ODD for the trial and required manual intervention. This suggests that effective safety drivers are an important tool in safety management when participants are exposed to self-driving technology – at least for the first time. When the ODD does not allow for a full range of driving situations, safety drivers are

also an essential tool for safe operation on public roads. Previous research has suggested that levels of trust increase if there is the possibility of manual take-over and a safety driver present (König & Neymar, 2017; Fernández *et al.*, 2018), which seems to be replicated as a finding here.

- "Matching the speed of the cars in front"
- "Safe distance from the cars in front"
- "Cautious. Good handling (e.g. roundabouts)"
- "It handled roundabouts better than a human"
- "Responsiveness of [safety] driver to challenging events"

Figure 6: Typical examples of reasons for a positive view of the safety of Five's ADS

Some of the areas where safety-related improvements were suggested included prioritising safety over passenger comfort (e.g. in braking events) as well as considering what passengers feel comfortable with regarding lateral lane positioning relative to kerbs and other vehicles in the scene (Figure 7). For safety reasons, direct interactions between Five's self-driving vehicles and vulnerable road users (VRUs) were restricted during the StreetWise trial. It was decided that such interactions would remain outside the ODD, therefore requiring safety drivers to take control when, for example, overtaking cyclists and avoiding pedestrians at uncontrolled crossing points. Comments from some participants suggested that this intervention from safety drivers was perceived as a limitation of Five's ADS. In fact, Five's software is able to detect and manage interactions with VRUs, despite them being excluded from the StreetWise ODD. Such perceptions highlight that it will be increasingly important to explain to the public how self-driving technology is tested and released iteratively, with strict ODD-based controls on scope of operation.

- "Unnecessary braking"
- "[Too] close to edge of road"
- "Too close to parked cars"
- "Recognition of cyclists and pedestrians - not sure how accurate this was"
- "Number of times manual override used"

Figure 7: Typical areas of improvement suggested for the safety of Five's ADS

The factors displayed in Figure 7 suggest things that could be improved, and which would improve feelings of safety for participants, and may affect their uptake of this technology in

the future. Participants gave further information as to what increased or decreased feelings of safety during their journey during the cognitive interviews (**Error! Reference source not found.**).

The post-trial interview started with the question of how safe participants felt on their journey in the trial vehicle. Participants were then asked what impacted their feelings of safety, to which there was a variety of responses. Themes that emerged following those three questions are displayed in Table 1 below, which complements the quantitative results from the post-experience questionnaire.

Table 1: Themes and subthemes from discussions around feelings of safety

Themes	Sub-themes
Initial feelings when asked about safety	- Completely safe or really safe - Partially safe - Met expectations of safety - Safer than expected - Safe despite events on route - Did not meet expectations of safety - Feelings of safety increased on the journey - Feelings of safety decreased on the journey
Factors that increased feelings of safety	- How the car is built - The presence of the safety driver and engineer - Trust in Five - The cautious nature of the self-driving system - The tablet, the visibility of the system and level of information - Reactive braking - The system taking over (self-driving mode) - Safer than or like a human driver - The route
Factors that decreased feelings of safety	- Sharper than usual braking - Braking distance - Not reacting as a human would have done - Misinterpretation of a hazard - Recognising right of way - Other road users - Cautiousness - Speed - Road positioning

- Readiness of technology

4.3.2 Rider smoothness ratings (overall) for the self-driving experience

Figure 8 shows the distribution of overall smoothness ratings from participants at the end of their self-driving experiences (mean smoothness rating was 58 out of 100). Two-thirds of participants (67%) had a generally smooth self-driving experience (indicated by a rating above '50' on the response scale). However, a relatively small proportion of participants (14%) reported what could be described as a 'very smooth' ride (indicated by a rating of 81-100). Indeed, a mean smoothness rating of 58 suggests that while Five's ADS provided a tolerably smooth experience, further optimisation of passenger comfort was needed.

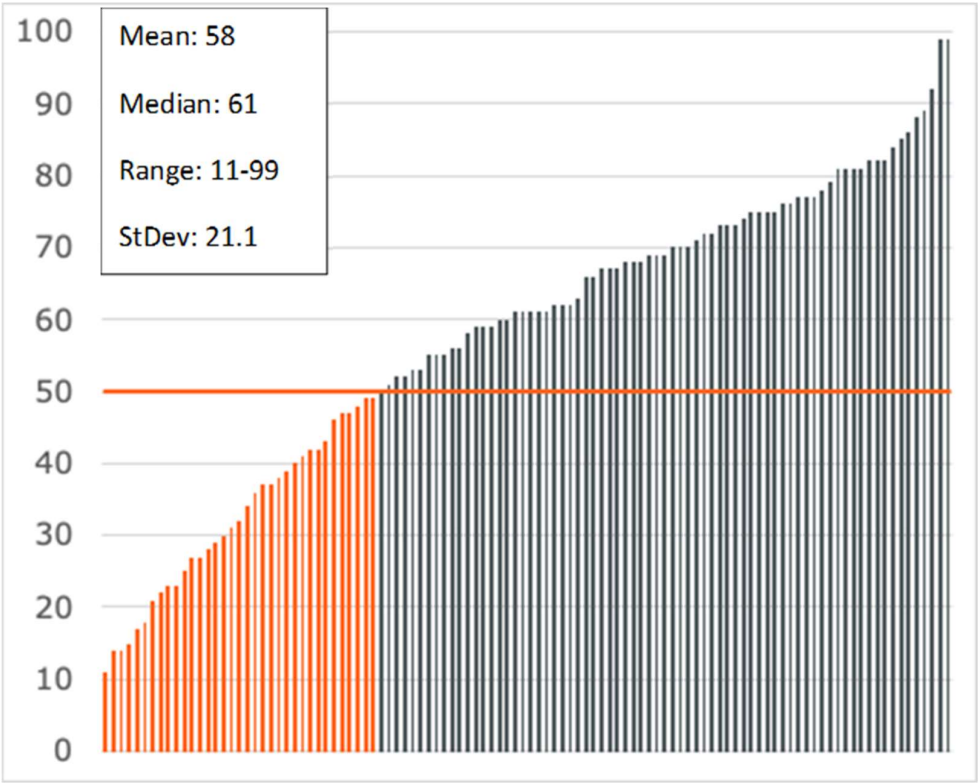

Figure 8: Distribution of individual participant responses for overall smoothness rating ('0' not at all smooth – '100' very smooth)

Riders were invited to give the three most important reasons for their smoothness rating. Several comments alluded to Five's self-driving vehicles demonstrating very 'human-like' driving behaviour, particularly for speed management and cornering (Figure 9). It would appear from the comments provided that Five has developed an ADS that avoids feeling 'robotic' with its motion control.

- "Generally good at maintaining speed"
- "Good at taking corners and bends"
- "Most of the journey was as if it was being driven manually"
- "On the whole the ride was smooth so that I became less aware that I was in an autonomous vehicle"

Figure 9: Typical examples of reasons for a positive view of the smoothness of Five's ADS

Nevertheless, some participants did identify further scope to optimise passenger comfort. In certain situations, the prioritisation of safety over passenger ride comfort manifested as sharp braking, steering or acceleration events (Figure 10). Five confirmed that during this trial it had still to optimise its ADS to provide more comfortable, human-like driving responses to developing traffic situations. Five also acknowledged that there would be further scope for its self-driving vehicles to consider road surface condition and minimise passenger discomfort (e.g. due to potholes) whenever it is possible to make such choices without compromising safety. Five explained that these types of features were not optimised at the time of the trial to demonstrate to in-vehicle participants but were planned for upcoming structured public road tests as part of Five's programme of continuous improvement.

- "Sharp braking"
- "Sharp steering"
- "Acceleration followed by braking"
- "Some light swerving in lane"
- "No solution for pothole avoidance yet"

Figure 10: Typical areas suggested for improvement of the smoothness of Five's ADS

4.3.3 Rider trust ratings (overall) for the self-driving experience

Figure 11 shows the distribution of participant ratings of trust in the ADS at the end of their self-driving experiences (mean trust rating was 67 out of 100). Four out of five participants (81%) generally trusted the ADS in their self-driving experience (indicated by a rating above '50' on the response scale). More than a quarter (27%) were very trusting of the self-driving system (indicated by a rating of 81-100), whilst more than a third of participants (36%) still reported a firm level of trust (a rating of 61-80). Given that this was the first experience of a fully self-driving vehicle for all participants, the high levels of overall trust in the system are noteworthy. Links between levels of trust and different demographics were investigated; however, no significant findings emerged, and are therefore not reported.

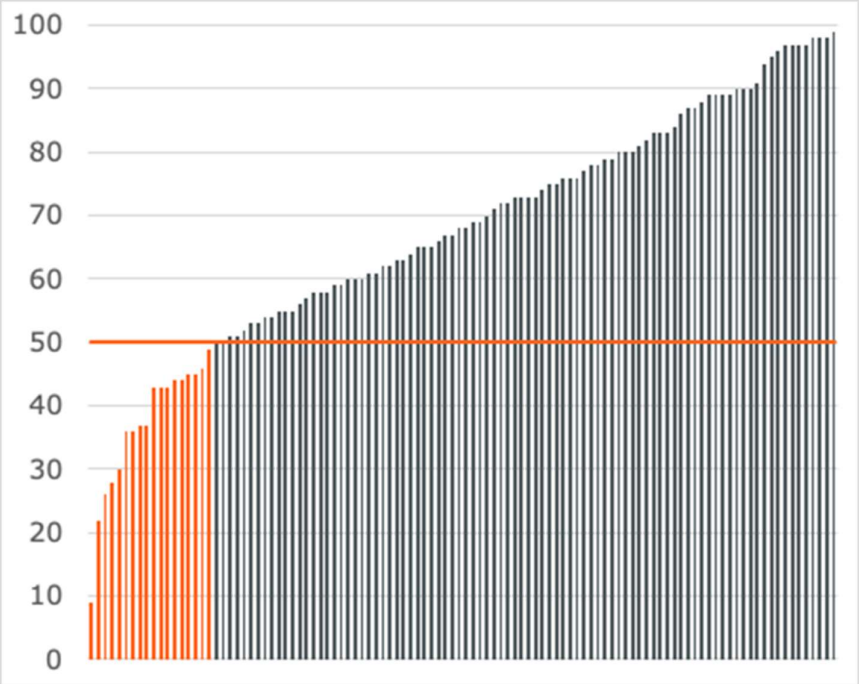

Figure 11: Distribution of individual participant responses for overall trust rating ('0' no trust at all – '100' complete trust)

Two key factors appeared to increase trust in Five's ADS: firstly, access to the Five 'visualisation tablet', which provided insight into the operation of the self-driving system for participants, and secondly, direct experience of the self-driving system handling manoeuvres that are complex for human drivers.

Participant interaction with Five's tablet visualisation system appeared to build trust (Figure 12). Each self-driving vehicle in the trial was equipped with a tablet between the front seats, viewable by the participants in the back. The tablet provided a combination of direct views from some of the sensors used by the ADS, a text description of current and upcoming actions, and a replication of the world around each self-driving vehicle using data from a range of sensors. As well as providing fundamental information about vehicle speed, direction and decision-making, it appears that the representation of other dynamic agents within the scene helped participants to establish that the ADS was safely and competently managing the driving task.

The types of complex manoeuvres that participants gave as examples for trusting Five's ADS included handling of complex roundabouts, speed management and responding to vehicles cutting in. Such comments tended to assign attributes that suggested the ADS was perceived to have 'intelligence' – some participants noted that manoeuvres were 'clever', 'capable' and 'well judged' (Figure 12). Such attributes might be used to distinguish human drivers from robotic systems. It could be that humans recognise from their own experience that such manoeuvres require complex perceptual tasks and layered decision-making. If a self-driving vehicle can emulate such skills, then it appears more trustworthy. One participant noted,

"successful experience builds trust", which echoes recommendations from prior research that such direct experiences have value in this regard.

- "Deals with roundabouts very well including complex ones"
- "Good roundabout manoeuvring"
- "Clever speed and braking"
- "Could handle cars pulling out in front of it and seemed capable of detecting what was going on"
- "Better than some cab drivers"
- "Car judged itself on the road well, drove carefully, at a good and safe speed"
- "Successful experience builds trust"
- "Seeing the other vehicles and pedestrians on the computer screen gave me a feeling that the system was aware of everything"

Figure 12: Typical examples of reasons for trusting Five's ADS

With a conservative approach to safety in the trial, some traffic and weather situations (e.g. medium or heavy rain) required that Five prioritised safety and took control manually. Some participants felt that this was an area for improvement (Figure 13); however, Five was always focused on safety rather than permitting the ADS to operate outside of its strictly defined ODD. This included situations where Five's safety drivers disengaged to ensure other traffic did not become impatient with the self-driving vehicles adhering to the rules of the road (e.g. keeping firmly to speed limits). This is because Five had experienced examples of frustrated drivers attempting unsafe passing manoeuvres and/or close following behaviour when they felt impeded or forced to drive at the prevailing speed limit. Five was keen to avoid such conflict situations in this first public road trial.

Some performance limitations of Five's in-car tablet visualisation system may have also affected participants' trust in the ADS (Figure 13). There were a small number of comments regarding technical restrictions of trying to replicate the output of a self-driving super-computer on a consumer-grade tablet reinforcing the importance of displaying to participants reliable, real-time information about the performance and decision-making of an ADS to help build trust, and de-mystify self-driving vehicles. This may affect future uptake of this technology, but further investigation would be required.

- "Could see phantom objects appearing on the [visualisation] screen"
- "[Tablet visualisation] didn't always place other vehicles in correct location"
- "When the visualisation didn't match the world outside it really makes you wonder how safe it is"
- "Frequent driver input"
- "Doesn't work in light rain yet"
- "Long time waiting at roundabouts"

Figure 13: Typical areas to improve trust in Five's ADS

4.3.4 Real-time participant ratings during the self-driving experience

Real-time measures were used so participants could rate their experience during the journey from Bromley to Croydon (Figure 14) and from Croydon to Bromley (Figure 15). These measures were collected on a visual analogue scale on a tablet, from negative to positive. Respondents were prompted ten times during each journey (five time points in each direction of the two-way journey) and each rider had their own tablet. The data suggest that the real-time ratings for their perceptions of the constructs of safety, smoothness, trust, and overall opinion of the driving system were relatively consistent across the five time points measured in each journey[3].

When exploring the real-time measures provided during participants' journeys, their 'overall' ratings at each time point tended to track their 'safety' ratings closely (and both were generally high on average), with trust and smoothness consistently rated slightly lower on average. The data also showed that responses regarding the perception of safety, smoothness, trust and overall experience were moderately positively correlated, suggesting that perhaps all of these components were evaluated as a whole rather than as individual factors[4].

[3] Analysis was undertaken to assess whether there was an order effect, e.g. relating to the direction of the journey; however, no significant differences were identified.

[4] Correlation coefficients ranged from 0.4 to 0.66.

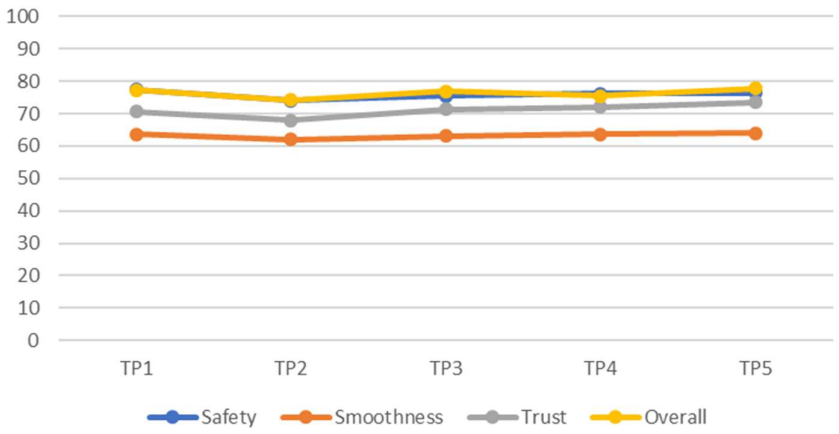

Figure 14: Mean scores for 'real time' measures of safety, smoothness, trust and overall experience (Bromley to Croydon, Time Points (TP) 1-5)

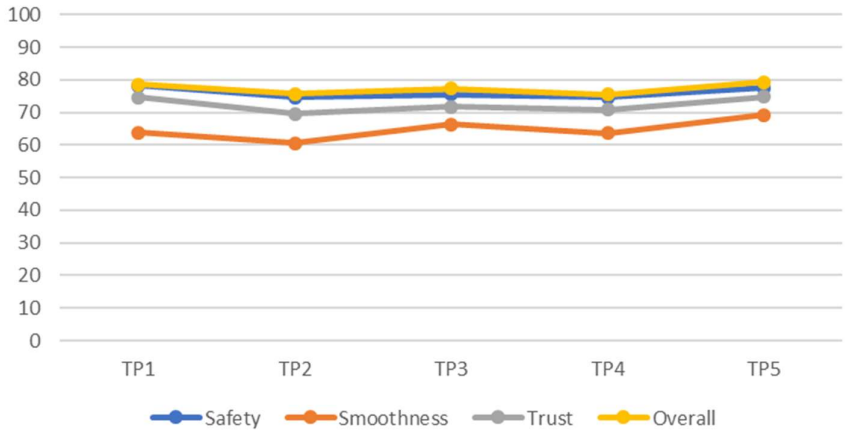

Figure 15: Mean scores for 'real time' measures of safety, smoothness, trust and overall experience (Croydon to Bromley, Time Points (TP) 1-5)

4.3.5 Rider ratings for the self-driving experience overall

At the end of the self-driving experience, in addition to being asked to rate their overall perceptions of safety, smoothness and trust separately, participants gave an overall rating for their entire self-driving experience (mean overall rating was 81 out of 100). Figure 16 shows that almost all participants (96%) had a positive self-driving experience (indicated by a rating above '50' on the response scale). More than half of all participants (56%) provided what could be described as a 'very positive' rating of their self-driving experience (indicated by a rating of 81-100). A further third of participants (35%) reported the equivalent of a 'moderately positive' experience overall (a rating of 61-80), when asked during the post-experience questionnaire.

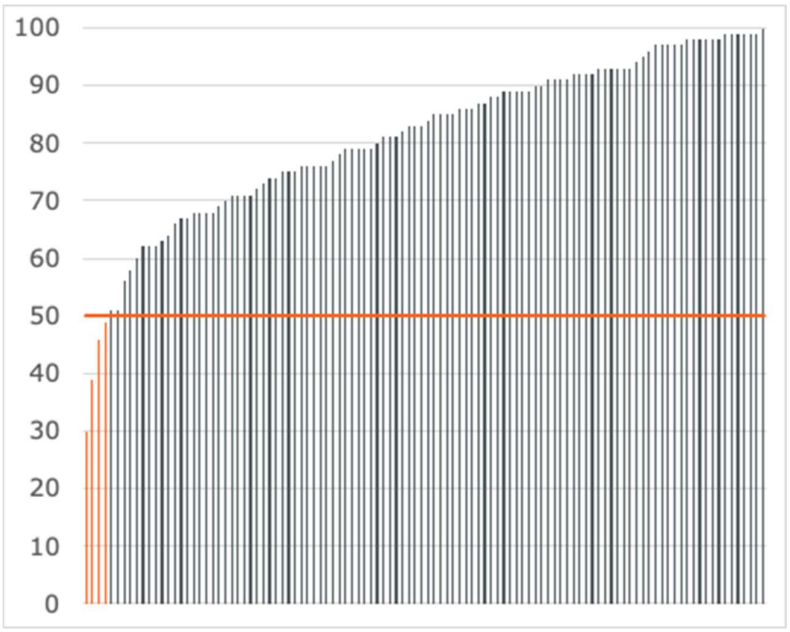

Figure 16: Distribution of individual participant responses for overall rating ('0' negative – '100' positive)

Figure 17 presents the mean ratings for the experience overall and for the separate factors of safety, smoothness and trust. The notably high overall ratings suggest that participants were probably using additional factors to evaluate their self-driving experience; such evaluations were not simply an aggregate of safety, smoothness and trust (although overall ratings were most closely aligned with safety ratings, which suggests that safety might be the dominant factor). If there were other factors at play when participants evaluated their self-driving experiences, assessment of the open responses provided indicate that ADS performance might perhaps be one, especially given the multiple comments that referenced how effectively Five's ADS managed a range of complex traffic situations.

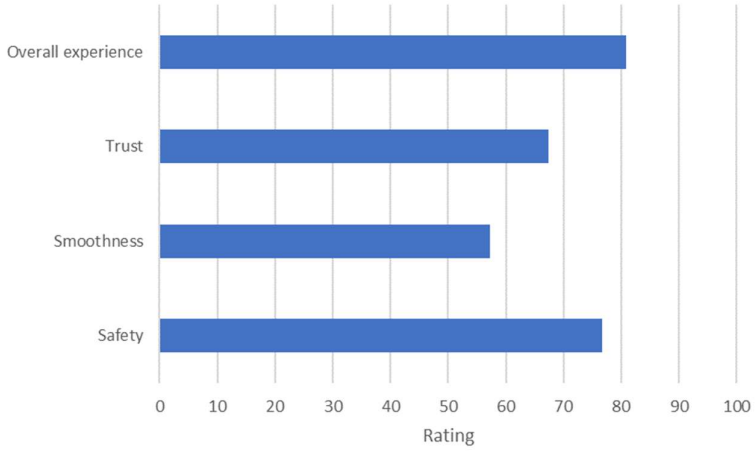

Figure 17: Mean self-driving experience ratings (post trial questionnaire)

4.3.6 *Expectations vs experience*

Riders were asked to rate how their self-driving experience compared with their expectations prior to the trial[5]. This was measured on a VAS ranging from 'much worse than expected' (0) to 'much better than expected' (100). The mean participant rating was 73, which suggests that participants generally had a better experience than expected (Figure 18). In fact, 86% of participants rated that their experience was better than their expectations (indicated by a rating over 50).

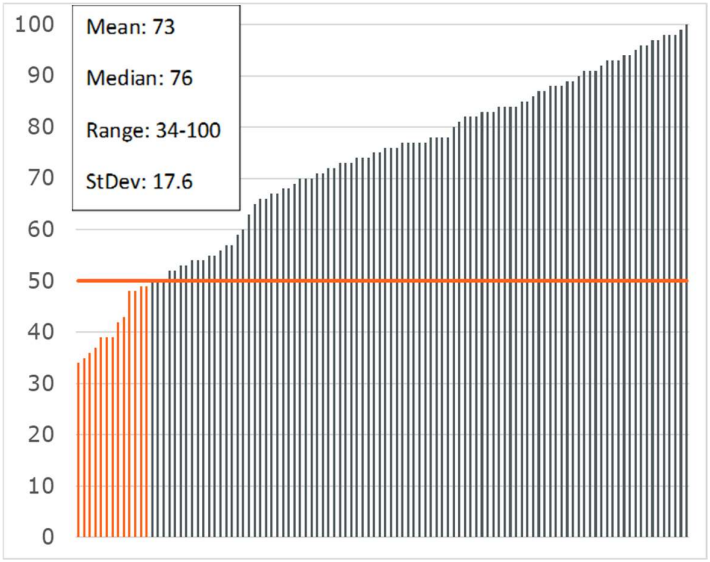

Figure 18: Distribution of individual participant responses for expectation vs experience ('0' much worse than expected – '100' much better than expected)

Qualitative analysis of the reasons why participants felt this way suggests several key themes for those who provided both high and low ratings:

- Amount of human intervention required
    - For some participants, intervention occurred more frequently than expected, and for others intervention occurred less frequently than expected
- Handling of different scenarios
    - For some participants the system handled different scenarios better than expected and for others it was worse than expected
- Smoothness of ride

Ride smoothness was better than expected for some participants and worse than expected for others.

[5] The question asked was, "How would you rate today's self-driving experience against your expectations?".

- The experience raised awareness of the capabilities and limitations of current self-driving technology
- Some participants had neutral or no expectations prior to the trial

Responses were classified as positive or negative; however, out of 100 classified open comments, most were positive. Figure 19 provides some examples of positive comments, such as less frequent intervention from safety drivers than expected, better automated handling of traffic situations, smoother ride than expected, and interactions with 'crazy' human-driven traffic.

- "Manged roundabouts and traffic lights better than I expected"
- "Ability to cope with real driving conditions was impressive"
- "The car was much more capable than I imagined"
- "I didn't think it could do everything, but it did"
- "[Media] tend to highlight problems rather than progress"
- "Driver and engineer were very engaging and informative and made the trip interesting"
- "London traffic is crazy!"

Figure 19: Examples of how the self-driving experience was viewed positively compared with expectations

Around a fifth of responses were classified as 'neutral'. For these participants, the experience provided welcome insight into current developments in-vehicle automation. As such, their responses reflected a more neutral take on the experience, highlighting both positive features as well as some perceived limitations of the technology.

Almost a quarter of classified responses were considered 'negative'[6]. It is important to note that qualitative responses categorised as 'negative' did not always correspond with a low score in the quantitative measure regarding expectations. In fact, out of the 23 qualitative responses categorised as 'negative', only 10 participants provided a score lower than 50. This suggests that even with stated demerits (examples in Figure 20), Five provided a self-driving experience that was clearly beyond the expectations of the vast majority of participants.

[6] This number reflects missing data (e.g. participants not providing responses) or responses that could not be assigned a positive or negative valence

- "Expecting more automation"
- "Frequent driver input"
- "Inability to do certain overtaking as well as drive over the lines on certain roads was behind what I expected."

Figure 20: Examples of how the self-driving experience was viewed negatively compared with expectations

Figure 21 shows participants' estimates of the percentage of the total journey that was self-driven. Riders estimated that Five's ADS handled a mean of 69% of the entire 13-mile trip; in reality, it was closer to 80-90% of the experience that was fully self-driving, on average. It is possible that multiple brief interventions for safety-related reasons (to keep the self-driving vehicles within the specified ODD) may have contributed to participants slightly under-estimating the actual proportion of the experience that was handled by Five's ADS.

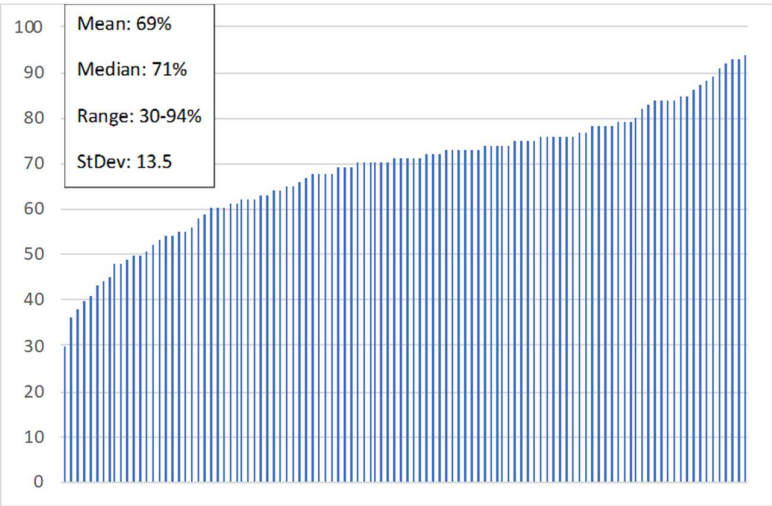

Figure 21: Distribution of individual participant responses for estimated proportion of total experience that was self-driven (%)

Analysis also suggested a link between the percentage of the total journey participants estimated was self-driven and their self-reported perception of journey smoothness and safety. Riders who estimated a higher percentage of the journey was self-driven also tended to report a higher smoothness rating; this would support some of the comments that were received regarding how Five's ADS was as smooth as (and occasionally better!) than a human driver.

In terms of safety the relationship was negative, as a lower estimated proportion of the journey completed in self-driving mode was correlated with a higher safety rating. This may suggest that participants felt more at ease when they believed a safety driver was in control

more often. Again, this corresponds with several comments received regarding the high safety standards demonstrated by Five's operators during the trial. However, the limited data for these associations suggests we cannot draw firm conclusions from such correlations.

4.4 Safety, security and trust

4.4.1 Are we measuring the right constructs?

The project sought to investigate how people define or think of safety, security and trust as concepts. This is a relatively new area of research and we have little evidence on how people think about (and therefore how they evaluate) these concepts. Having a clear framework (that is based on direct exposure to the technology and services in question) will enable research to find clearer, actionable insights that can lead to better acceptance and uptake of automated vehicles and new services. The post-trial interview explored the use of these concepts through multiple questions; the results of which are discussed below.

Interviewees were asked what each of the constructs of safety, security and trust meant to them, in general, and to describe the thinking that helped them arrived at that definition. The following themes emerged and are displayed in Table 2.

Table 2: Themes that emerged from participants' definitions of safety, security and trust

Concept	Definition of concept
Safety	- Being free from risk, harm and pain - Physical phenomenon - Emotional phenomenon - Protection of self and others - A set of rules or norms - A neutral environment or safe 'bubble' - Security
Security	- Similar to safety - No worries - Protection or prevention - Emotional phenomenon - Physical phenomenon - An action or procedure - Reliability or predictability - A risk you are willing to take

Concept	Definition of concept
Trust	- Emotional phenomenon - Responsibility - Reputation and experience - Predictability - Relationship - Protection - Transparency - Reliability - Safety and security

As part of the qualitative interview, the researchers asked participants to state what they associated with each construct by articulating the first thing, person or event that came to mind when each of construct of safety, security and trust was mentioned. Figure 22, Figure 23 and Figure 24 present these responses.

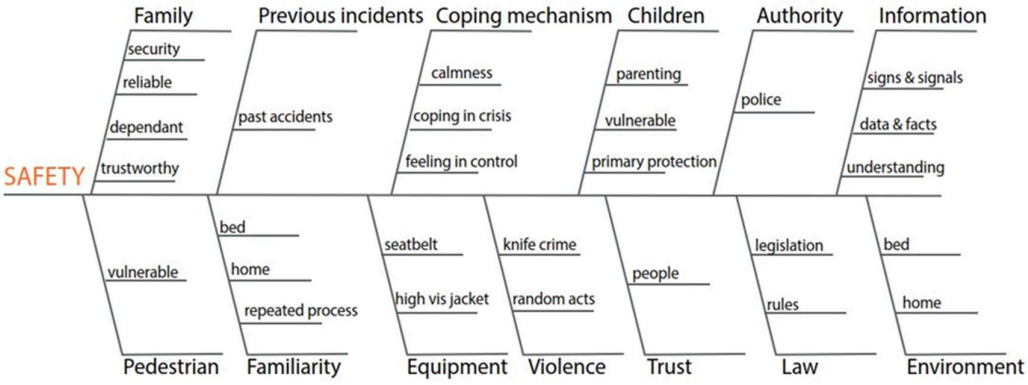

Figure 22: Themes and subthemes of factors associated with safety

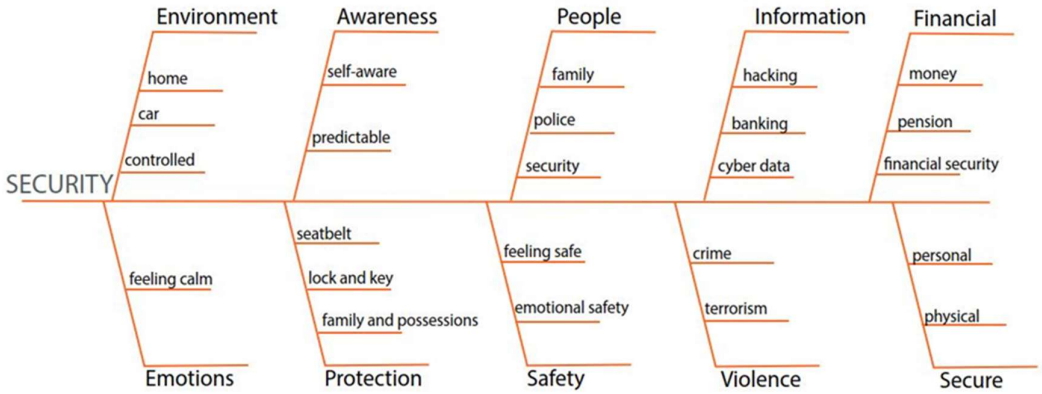

Figure 23: Themes and subthemes of factors associated with security

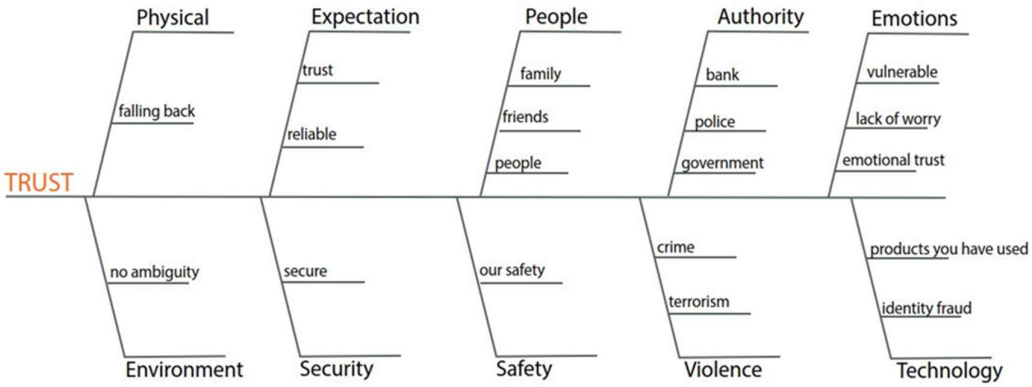

Figure 24: Themes and subthemes of factors associated with trust

The project wanted to investigate if the three constructs are considered to be different, in particular safety and security. The similarities and differences between safety and security, and safety and trust were compared by interviewees.

Participants were asked if they perceived there to be a difference between safety and security. Mostly participants stated that they thought they were different concepts, even if they overlapped. The similarities between the two concepts were described as “interchangeable”, “one enables another”, both involve protection, or there is no difference. Sometimes there were definitions of safety that described another respondent’s distinct view of security and vice versa. This shows us that the definitions of these concepts were not unanimously agreed amongst participants. The similarities and differences between safety and security that were identified by participants are shown in Figure 25.

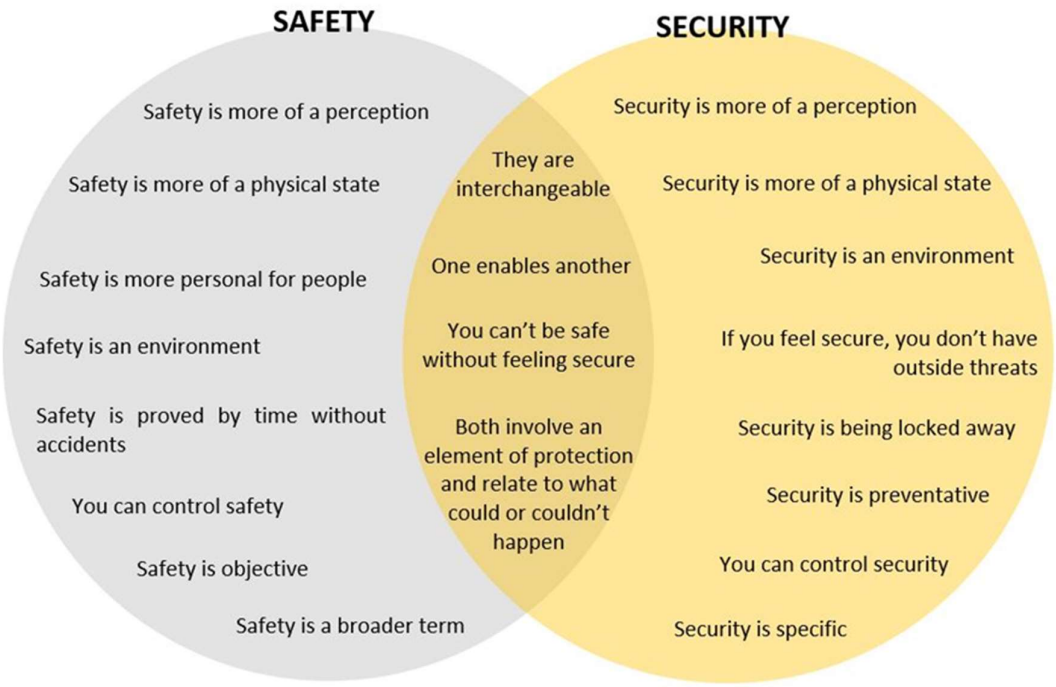

Figure 25: Venn diagram displaying the similarities and difference that were identified between the concepts of safety and security

The themes that emerged show that there is an overlap between participants' definitions of safety and security. What one participant may refer to as security may be another participant's definition of safety. It showed that although a participant may be confident in their own understanding of the word or concept, it is not necessarily a stable definition across our sample. It would suggest that safety and security are viewed as very similar concepts across the sample.

When comparing safety and trust, participants could articulate distinct differences between these constructs. Examples of this include whether each construct is an emotional or physical state and whether it's something there is 'just there' or not or needs to be built up to be present. Figure 26 suggests that people have a clearer idea about the differences between safety and trust. There was debate about how interlinked they are, and whether one leads on from another. There was an over-arching theme that safety was more physical when compared to trust, which is more emotional or subconscious. There were also some similarities between them, for example some participants associated both safety and trust with an assumption of not coming to harm, either as a state or a belief. An overlap emerged, in that one may need to feel trust in something to feel safe and vice versa.

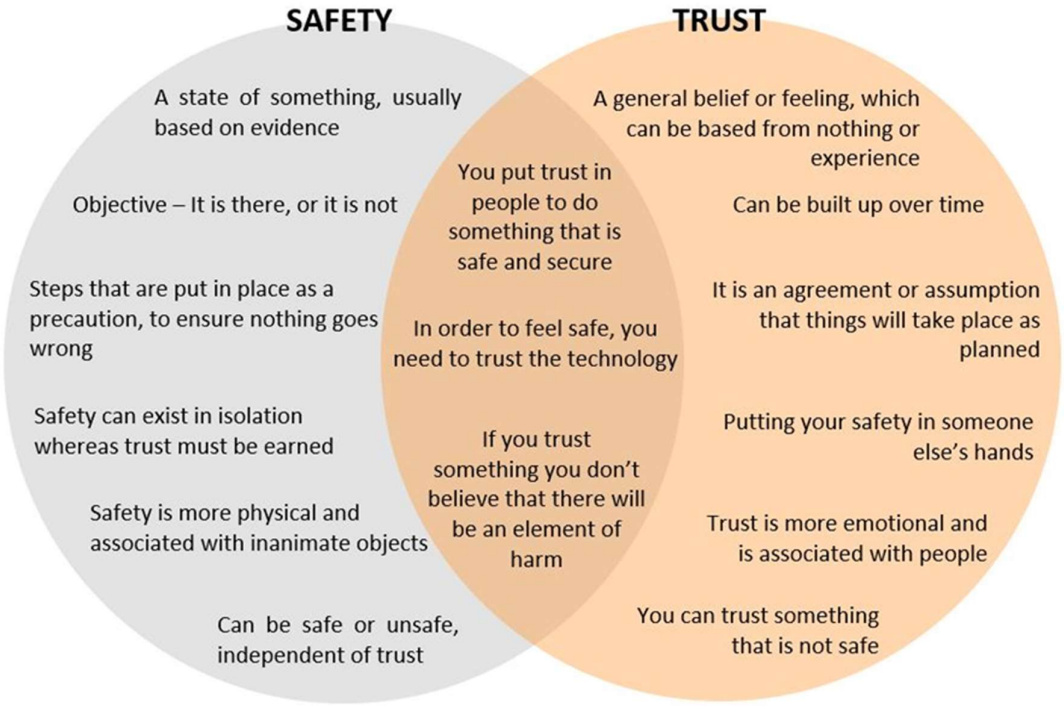

Figure 26: Venn diagram displaying the similarities and difference that were identified between the concepts of safety and trust

Thinking about how we measure constructs, people tend to find it difficult to differentiate safety from security. This means that future research needs to be careful in how questions and items are worded in order to assess the right thing and the intended aspects of the experience.

Previous research has suggested that you need safety to build trust; however, there is limited evidence of this from the current study. Our qualitative findings suggest that safety and trust are related for some participants, but potentially not all. For those where they believe it is linked, they believe you need to trust something to feel safe or be safe to feel trust. There are still discrepancies here. Generally speaking, the findings also indicate that all three concepts are very interlinked, though there are some differences for example in relation to the 'information' aspect. Security can be more related to things like hacking and cyber security – but not always – and safety uses information such as certifications or standards. As such we should be cautious about the validity of these measures.

4.5 Perceptions and previous experience of ridesharing

The research aimed to look into the impacts of previous experience of ridehailing or ridesharing[7] on perceptions and experiences during the trial. Very few participants (less than 30%) reported having used ridesharing services in the past (Table 3), whether commercial services (such as UberPool or BlaBla Car) or 'ad hoc' arrangements, such as arranging to rideshare with a colleague or co-worker.

Table 3: Frequency of previous experience of ridesharing (*N*=110)

	Ridesharing Services (e.g. UberPool, BlaBlaCar)	Other forms of ridesharing (e.g. commuting to/from work with a colleague)
At least 1 day per week	1	1
A few times a month	7	4
A few times a year / only for certain occasions	22	16
Never	75	84

There was a question about the relationship between prior experience of ridesharing (i.e. those reporting they have used this service in the pre-trial survey) and reported feelings of ridesharing post-trial. There was some suggestion that experience of ride*sharing* had a positive impact on feelings of ridesharing post-trial (significant difference at 90% level). However, it was found that prior experience of ridehailing (which was far more prevalent) did not have a significant impact on feelings of ridesharing post-trial. It should be noted that the trial itself was a managed process (without a user app or any control over time and the origin/destination of the ride), therefore it cannot be suggested that the trial experience itself provided a first example of a ridesharing service for those who had not used such a service before (especially as some participants rode alone). However, the trial experience and the accompanying survey questions did certainly elaborate on the definition of ridesharing, thus the overall experience of participation may have improved people's general understanding and awareness of this type of service compared with before they took part.

The research explored **how likely participants were to use a self-driving ridesharing service if it was available in their area**. The results showed that invited participants who took part in the trial were willing to consider the use of a self-driving ridesharing service as part of their daily commute, if this were to become available. As such, 67% of participants reported being either likely or very likely to use such a service, while only 19% reported they'd be unlikely or very unlikely to use this service.

[7] Once again, note the distinction between the two modes, with ridehailing referencing private, individual use of services such as Uber, and ridesharing referencing shared use of such services (e.g. UberPool), typically with strangers or people from a different household.

When considering willingness to pay, participants were asked to assess how much they would be willing to pay to use each of the following options for this 6.5mile on-way section of their usual commuting route:

- A shared ride in a larger, multi-seat automated vehicle (similar to the vehicle presented to participants in a concept video during the survey)
- A private ride in a smaller vehicle, like the one experienced in the trial

For context, participants were provided the approximate cost for other transport modes for the same on-way journey (quoted as about £17 for a London taxi, about £15 for an Uber or similar ride-hailing service, and £1.50 to use the bus). As participants were generally familiar with the commuting options, they would also be aware that a taxi or ride-hailing service would provide a similar journey duration to the self-driving vehicle, whereas the bus would take at least twice as long (typically over an hour). Overall, the amount in pounds sterling (£) that participants were willing to pay for this one-way section of their usual commuting route was lower for the shared vehicle (mean £5.50), than for the private AV ride (mean £10.90. There was a mean difference of around £5 in the price participants would be willing to pay for a private vs a shared ride (using the parameters of the journey undertaken during the trial as a benchmark).

Interestingly, the data suggests that the highest difference was not between those who were most likely and least likely to use this type of rideshare service (average difference of £5.30, and £5.50 respectively), but those who reported they were neither likely nor unlikely (average £6.50). However, it is important to note that only a small proportion of participants' responses were in the neutral category. There was also a lot of variability in responses, as can be seen in the histogram (Figure 27).

In future research, there could be more focus on the difference between current journey times and distance, and willingness to use the service.

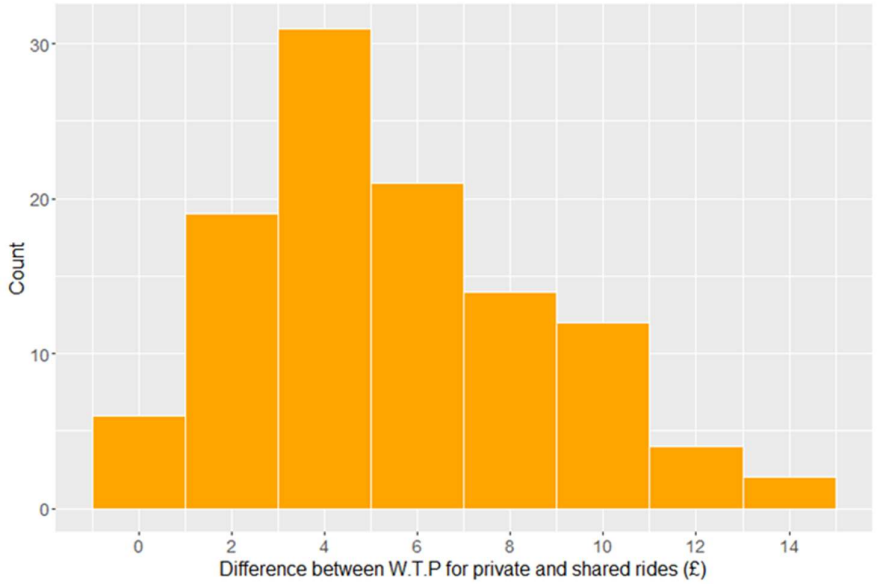

Figure 27: Distribution of the difference between how much participants were willing to pay for private and rideshare services

4.6 AV and AV ridesharing as future mobility options

The research team aimed to explore whether an uptake of self-driving vehicles may decrease the number of road users that would otherwise opt to walk or cycle. Participants were asked which transport modes they would expect to use more or less if self-driving, multi-passenger vehicles were available to them (Figure 28).

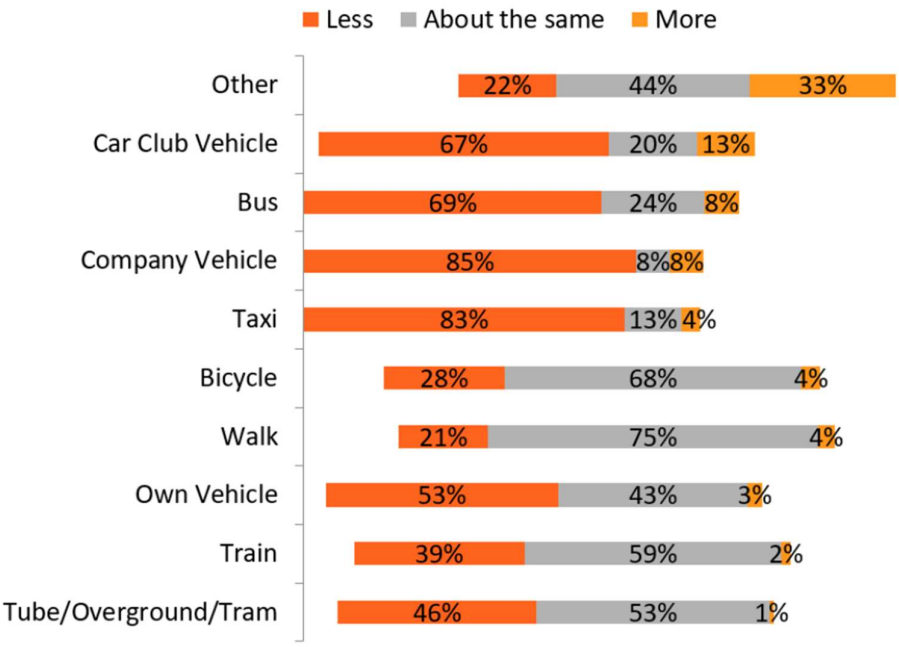

Figure 28: Responses to "If multi-passenger self-driving vehicles were widely available in the future, would you expect to use the following transport modes more, less or about the same as you do currently?" (in percentage)

Participants' responses do not suggest a mass decline in the intended future use of sustainable transport options such as public transport, walking and cycling. Bus use did, however, emerge as one of the sustainable transport modes participants would opt to use less of, if shared AVs were available. This is not a surprising outcome, particularly as previous research has suggested that bus transport is not always highly rated by participants and issues such as reliability and comfort are often discussed within the literature (Hu *et al.*, 2015; Dobbie *et al.*, 2010). It is also worth noting that participants may have been basing their opinions on modal comparisons for the route they experienced during the trial, where the available bus service is not as direct as it could be (this was one of the reasons for selecting the route for StreetWise).

In terms of single occupancy transport, although on average participants did not necessarily think they would use their own vehicle less, other forms of transport such as company vehicles and taxies could be used less if a self-driving ridesharing service were available.

Where participants have stated that they would use a transport mode less often, it is important to note that this does not mean that they intend to completely replace that transport mode with a self-driving vehicle. It means that they may consider using it sometimes, and the as a consequence use of other modes may reduce. That being said, these findings are important to highlight now, so that services can be designed to have minimal impact on sustainable public transport modes and can complement existing provisions where appropriate. This will allow for selective marketing and tailored campaigns about self-driving vehicle services in the future and highlights why research in advance of changes is so beneficial for a seamless and sustainable integration of vehicle automation.

4.6.1 What role do people see shared self-driving vehicles playing in their mobility?

Participants were also asked about the types of journeys for which they would use a self-driving multi-passenger vehicle service. Figure 29 shows the proportion of responses for each category.

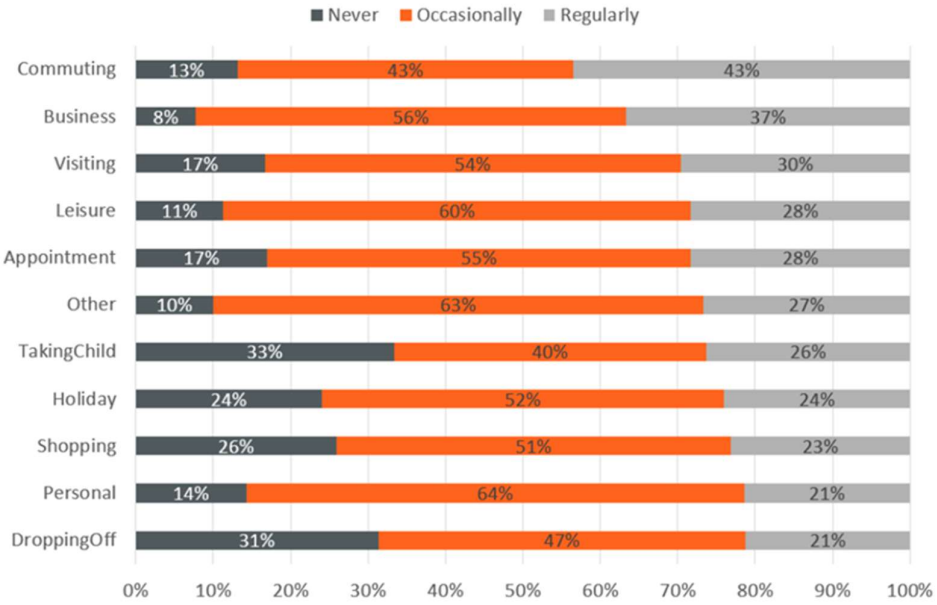

Figure 29: Proportion of responses to question "How often do you think you would use self-driving, multi-passenger vehicles for the following purposes?"

The data suggests that participants would be comfortable using this type of service regularly for commuting and business trips.

Interestingly, taking or collecting a child to/from school as well as picking up and dropping someone off were less likely to be preferred. This type of finding has been pre-empted within the industry, and within the limited evidence available there is some suggestion that

transporting children (especially unaccompanied) is a key concern regarding the use of AVs more widely[8].

4.7 What should the industry do in the future?

The post-trial interview concluded by asking participants what they think the industry would need to focus on to encourage consumer uptake of self-driving ridesharing services. Participants discussed what may persuade them to be more likely to make self-driving journeys in the future, as well as what the industry should develop for the implementation of such vehicles. The following themes emerged from interviews with participants and are displayed in Table 4.

Table 4: Themes discussing what participants thought the industry should focus on in the future

Themes	Further detail
Availability	Automated vehicles welcomed to places/routes with a high number of potential users but where other transport services are currently irregular or indirect. There are some routes that are only accessible by walking or cycling, with the absence of a connection to public transport, which could be aided by this type of system. Sufficient availability of automated vehicles to cover peaks in demand would be desirable to consumers.
Convenience	Promoting the idea of having more time to relax on a journey compared with driving yourself. Also, if convenience matched or exceeded that of private car ownership, participants felt consumers might be more convinced to change their commuting mode from private cars.
Trust in new technology	It was stated that people are generally resistant to change; therefore, trust needs to be built and maintained. The media could be used to explain the benefits of self-driving vehicles to the public, but general exposure will be likely to increase trust, as well as further (free) public trials and the absence of any safety-related incidents or collisions.
Journeys	A benefit to be advertised was the potential for quick journey times due to the concept of requested pick up points, as well as the reliability and timeliness of the service compared with other modes.

[8] One example of this was the termination of a project in the fall of 2018 being undertaken in the state of Florida. The project, being run by the company Transdev, used an EasyMile pod to carry school children three blocks on private roads within a private community. The National Highway Traffic Safety Administration (NHTSA) intervened and ordered for the trials to be stopped, citing public safety as a key motivator due to the vehicle being considered non-compliant for the transport of a vulnerable population.

Price	Consumers would want it to be affordable, ideally by price-matching or undercutting private ridehailing services such as Uber (or – more controversially – other commuting modes such as bus or train). Participants queried having no driver would lead to reduced costs for the consumer, hinting at possible consumer expectations on pricing.
Mobility	There should be an increased benefit for vulnerable or elderly people that currently have difficulty with mobility or are unable to drive. An example of a use case for this was as a possible aid to NHS transport (e.g. a discharge transportation service from hospitals).
Environment	Automated electric vehicles (or those with zero emissions at the tailpipe) would present a positive impact on the environment. Participants could see the benefits of ridesharing for lowering pollution, the carbon footprint and CO_2 emissions. It was acknowledged by participants that even if the self-driving industry could offer services that contributed to cleaner air, this would not always match or better other existing transport modes.
Regulation	The public will want to know how self-driving vehicles are regulated and how thoroughly they have been safety-tested, as well as who is liable in the event of a collision.
Safety	Participants were interested to find out more about how the vehicle would react to different scenarios. They thought the public would be interested to know how its behaviour compares to that of a human driver. There were suggestions of a safety standard which would award a certification mark, that people would be able to understand and recognise (e.g. the CE mark).
Education	Participants suggested that the public should have more understanding of how self-driving vehicles operate, (e.g. it could be integrated into conventional driver training and education – although conversely, those future users may not ever undergo conventional driver training for the purposes of obtaining a licence).

5 Discussion

The StreetWise trial offered an insight into the future services that might be available using the technology provided by companies such as Five. It gave potential future users experience of self-driving vehicles operating in complex, real-world environments, interacting with other road users in live traffic situations and with a clear-cut use case (connecting transport hubs). A positive result was that the vehicles were able to self-drive for longer and in more complex situations than in previous studies such as GATEway[9], Autodrive[10] and VENTURER[11].

The self-driving experience in StreetWise demonstrated the factors which effect the uptake of this technology. With these barriers being addressed in the future, a self-driving ridesharing experience has the potential to provide an additional sustainable commuting option by reducing the number of trips made in single occupancy internal combustion cars (ideally with low or zero emissions at the tailpipe).

The findings from the StreetWise trial built on work from previous research into public perception of self-driving vehicles, as well as providing new insights that have not been explored previously and using 'real time' measures. The direct exposure that these users have experienced has allowed us to uncover some of the true benefits and unintended consequences associated with the uptake of AVs.

This study focused on participants' **journey experience** (expressed using concepts of safety, security and trust, and ratings of ride smoothness, overall experience and prior expectations) and factors affecting **AV uptake** (previous ridehailing/sharing experience, willingness to pay/use, intended journey purposes, estimated future modal preferences, and recommendations for industry priorities). This feedback will help to guide the industry towards developing automated mobility solutions that are accepted by the public.

5.1 Journey experience

Overall, most participants felt safe and had a positive self-driving experience. Safety is an important consideration for occupants of a self-driving vehicle and the StreetWise consortium always prioritised occupant safety. Participant ratings for safety, trust, smoothness and overall experience were relatively consistent throughout the journey. Smoothness was the construct with the lowest participant rating, but also the highest variability in score. This could indicate that smoothness is the most sensitive measurable construct. It is suspected that smoothness is journey specific, which could explain the variability even when trialling the same route. The data showed perceptions of safety, smoothness, trust and overall experience were moderately positively correlated. This means that the factors are interlinked and when

[9] Fernández-Medina K, Delmonte E, Jenkins R, Holcombe A and Kinnear N (2018). GATEway Trial 1: Deployment of a micro-transit vehicle in a real-world environment. (PPR858). Crowthorne: Transport Research Laboratory

[10] About UK Autodrive (2020) [online]. [7th July 2020]. Available from World Wide Web: http://www.ukautodrive.com/the-uk-autodrive-project/

[11] The VENTURER Project (2020) [online]. [7th July 2020]. Available from the World Wide Web: https://www.venturer-cars.com/venturer-project/

one increases, so do the others. This suggests that the constructs were evaluated as one rather than as individual traits; participants were reporting having a generally positive or negative experience across all rated constructs.

When exploring acceptance and uptake of emerging technologies it is important to understand how people interpret the constructs they are discussing. This is evident from the variability of scores surrounding journey smoothness, as well the varying definitions of safety, security and trust elicited during the cognitive interviews. The trial gave an opportunity to understand what people think about when asked about the three constructs of safety, security and trust. There were overlaps and contradictions between participants' definitions of safety and security. Participants may be confident in their own understanding of the concept; however, there is not a stable definition across the sample. As such we should be cautious about the validity of these measures. The difference between safety and trust was more distinct: participants articulated this more clearly. It is worth mentioning that security, as well as reliability and privacy, has previously been associated with increased feelings of trust in automated technology (Kaur & Rampersad, 2018). It may be possible to infer that with such blurred distinctions between the definitions of safety and security, safety is another factor to be considered to impact on the trust of participants experiencing automated technology. Future research needs to be careful in how questions are worded in order to assess the correct intended aspects of the experience.

The self-driving experience generally exceeded participants' prior expectations. Even among those who had an experience that did not quite meet their expectations, most were not dissatisfied. Variation between expectations from the experience and reality were influenced by a range of factors such as the amount of human intervention required, handling of different scenarios, smoothness of ride, raised awareness of technology limitations, or having neutral/no expectations.

A higher estimated proportion of the journey in self-driving mode was correlated with a higher safety rating. Given the limitations of this finding, future research could investigate how to ensure that occupants of self-driving vehicles feel safe and trust the ADS as much as they would a good human driver.

The factors that increased participants' feelings of safety, such as the tablet providing visible information about the self-driving system, should be considered as future tools for such purposes. Meanwhile the aspects which decreased participants' feelings of safety such as misinterpretation of a hazard or recognising right of way should be addressed in order to improve the user experience.

Previous research has shown that feelings of safety have a direct impact on intention to use self-driving vehicles (Panagiotopolos & Dimitrakopoulos, 2018); therefore, this should continue to remain a priority to increase consumer acceptance and uptake.

5.2 Uptake

Less than 30% of participants had previously used ridesharing services. Prior experience of ridesharing had a positive impact on feelings of ridesharing post-trial. This shows that exposure to similar services increases the likelihood of uptake, which could encourage the adoption of self-driving mobility services.

Most participants (67%) were willing to consider the use of a self-driving ridesharing service as part of their daily commute if this were to become available. This could reduce the number of single occupant cars on the road. This type of service could also improve users' commute if they currently have an inconvenient, disjointed multimodal commute. Likewise, participants were asked how they could see this new transport option fitting in with their daily transport needs. Participants reported that they would be comfortable using this type of service regularly for commuting and business trips, whereas taking a child to/from school as well as picking up and dropping someone off were less preferred.

There was a lot of variability in participants' willingness to pay for a private ride in a smaller vehicle (similar to the trial vehicles) or a shared, larger multi-seat AV. There was little difference between those who were most likely and least likely to use this type of rideshare service. This could suggest that cost is not the definitive factor as to why people would or would not engage with such a service.

The next part of the research focussed on how possible future users would engage with a self-driving service. Participants were asked which transport modes they would expect to use more or less if self-driving, multi-passenger vehicles were available to them. Responses did not suggest a mass decline in walking and cycling; however, the transport mode that people would opt to use less was the bus. Previous research has suggested that bus transport is not always rated highly due to issues such as stopping, reliability and comfort (Hu *et al.*, 2015; Dobbie *et al.*, 2010). However, a self-driving service might also reduce reliance on other transport modes; for example, participants also favoured it overuse of a company car or taxi.

We then discussed with participants what may persuade them to be more likely to make self-driving journeys in the future, as well as what the industry should develop for the implementation of such vehicles. The emerging themes and pressing issues such as availability, convenience and mobility are explained in Table 4, these should be addressed to ensure that the service will meet the predicted needs for the customers. Taking consumer needs into account should ensure high uptake of the service and ensure that it is more likely to be accepted.

6 Conclusions

Five's technology has the potential to unlock self-driving mobility services that could provide green, safe, efficient and accessible transportation to end users, through electric, self-driving vehicles, with the aim to reduce elements of human error associated with the driving task (Department for Transport, 2015). The StreetWise participant trial has shown that people will be receptive to self-driving services once the limitations have been addressed. The findings show that most participants would be happy to consider the use of this service for commuting amongst other purposes. The findings reveal that the service would supplement eco-friendly modes such as walking and cycling while allowing participants to consider whether they would use other modes of transport (e.g. bus or taxi) less regularly than they currently do. Although what was done here was a good direct comparison with existing modes specifically on the test route, more research should be done into other locations, as well as into willingness to pay and comparison between currently available transport modes (although it was found that money probably was not the primary factor in willingness to use).

The things that made passengers feel safe within the vehicles should be maintained and promoted whilst the things that decreased feelings of safety should be focussed on to improve the self-driving experience for end users. Self-driving services should also aim to incorporate the themes identified by users when they were asked about what would make them more likely to engage and what industry should focus on; these factors should guide the development of the technology to suit user requirements.

Passengers mostly had a better experience than they expected and those with prior ridesharing experience had more positive feelings post-trial; this indicates that exposure is important for uptake and acceptance. The study highlights that more needs to be done for occupants to trust a self-driving vehicle as much as a human driver.

This research is key in understanding the concepts which are used when assessing user acceptance and uptake such as safety, security and trust. We also identified that safety, smoothness, trust and overall experience seem to be evaluated as one.

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StreetWise trial: Findings report

As automated vehicle (AV) technology continues to grow, along with its opportunity to become a viable commuter transport solution, it is essential to understand people's attitudes and perceptions towards the technology and their likelihood of engaging in their daily lives. The StreetWise passenger trial explored the perceptions, experience, and uptake preference of a hypothetical self-driving service and of participants' experience in an automated car.

The trial included a pilot phase and a trial phase; in total 110 participants had an experience in the vehicle. Participants completed a pre-and-post experience questionnaire as well as filling in real-time measures during the journey. Some participants took part in a short interview after the trial to gather further information about participants' attitudes towards self-driving vehicles.

The results show that the participants had a positive overall journey experience (including ratings and feelings of safety, security, trust, smoothness, overall experience and expectations) with safety being the most important consideration. Additionally, the data suggested that participants were more likely to use self-driving services for commuting and business trips but less likely to use them for transporting children. Other factors considered were previous ridesharing experience, willingness to pay, modal shift and what industry should focus on as a priority.

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