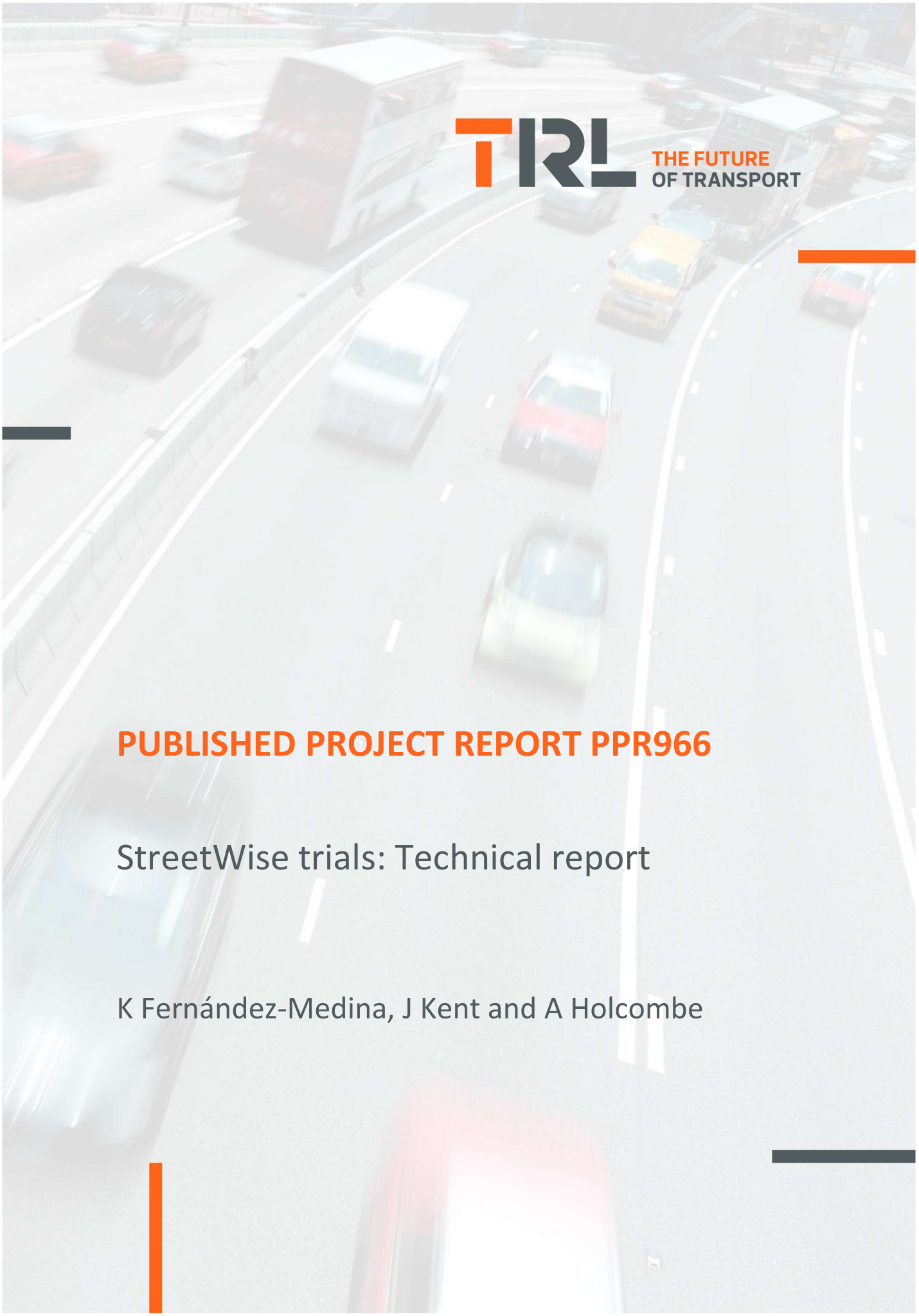

THE FUTURE OF TRANSPORT

PUBLISHED PROJECT REPORT PPR966

StreetWise trials: Technical report

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Report details

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1 Background

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 and how any new transport option may fit in with people's daily transport needs requires direct exposure to such technologies. Only by providing members of the public with access to new technologies can we assess the true benefits and unintended consequences. This was highlighted through previous research, where participants of a self-driving vehicle trial in London (GATEway) highlighted how physical trials of AVs could help build trust in this technology (Fernández-Medina *et al.*, 2018).

The trials that will be discussed in this report, undertaken as part of the StreetWise project, 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. The research undertaken 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 operated the research trials in close collaboration with Five, which was responsible for providing the self-driving experience.

1.1 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. Other consortium partners include:

- TRL
- Direct Line Group
- Oxford University Torr Vision Group
- McLaren Applied Technologies
- Warwick Manufacturing Group
- Claytex
- Transport for London

Funding for the project comes from the Industrial Strategy Challenge Fund and was delivered via Innovate UK, with other investment coming directly from industry. With safety as the first priority, a Safety Case[1] has been developed by TRL in line with the government Code of Practice and to meet the necessary legal requirements to conduct testing on UK roads and secure insurance for the trial. The Safety Case outlines all the requirements that have been satisfied in order for the trials to take place.

1.2 What makes this work different?

The research we have undertaken as part of the StreetWise project is different to previous research in a number of important ways. The work provides:

- A focus on the demonstration of self-driving technology within a clear-cut use case (i.e. demonstrating a shared automated vehicle transport with London commuters in mind)
- Real-world insights from a road-ready self-driving vehicle interacting with other road users in live traffic situations
- Real-world rider experience of AVs within a complex road environment tackling a variety of road features that participants would not have experienced before (e.g. roundabouts, junctions, signalised crossings, busy and mixed traffic)

1.3 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.

These insights can 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 reduce single occupancy vehicle journeys
- Direct future research that increasingly focuses on opportunities and challenges to achieving uptake of AVs and new services
- Understand what measures are appropriate and effective in understanding behaviour within this new context

1.4 This report

This report contains the details of the set up and running of the participant trials, as well as a detailed breakdown of the sample characteristics.

The findings from the research are detailed in a separate report, StreetWise trials: Findings report (Fernández-Medina *et al.*, 2020).

[1] https://trl.co.uk/reports/streetwise-abridged-safety-case

2 Method

2.1 Vehicle

Figure 1 provides an overview of the standard vehicle platform to be used during the trials.

Figure 1: Trial vehicle example

2.1.1 Platform

The vehicles used in the trial were 2015-17 Ford Mondeo Hybrids[2]. The vehicle features are as follows:

- 5-star Euro NCAP vehicle
- The vehicle's standard ADAS systems have not been modified or disabled
- The vehicles retain the standard controls for a human driver
- The modified vehicles provide the same field of view from the cabin (none of the vehicle modifications impact on this element)
- The vehicle remains as conspicuous as a production vehicle of this type

[2] At the time of the StreetWise trial, Five operated a fleet of 8 self-driving vehicles, with 2-3 of these vehicles made available on each trial day.

- Warnings to road users can still be issued by the safety driver using standard controls, such as lights and horn

2.1.2 Sensors

A number or sensors have been incorporated into the vehicle to enable the Automated Driving System (ADS)[3]. This includes a combination of stereo cameras, radar and Lidar units.

Daily checks were undertaken to ensure each self-driving trial vehicle was fully functional and performing to the required standard.

2.1.3 Safety drivers

In the UK it is currently a legal requirement to have a safety driver or safety operator ready and able to override the vehicle at all times (Centre for Connected & Autonomous Vehicles, 2019).

The trial vehicles were operated by trained safety drivers and engineers from Five. Five has developed a training protocol in order to set a high standard of performance and minimise the risk of harm.

The safety driver training program includes:

- Putting drivers through advanced driver training and a hazard awareness course
- Training drivers on the software capability and test this training through fault injection testing on a private test track
- Monitoring the compliance of drivers through in-vehicle cameras
- Regular training reviews and updates

In addition to the safety driver, a Five engineer was also present in the vehicle during the trials. The engineer's role was multifaceted and included monitoring the health of the system throughout the journey. They did not have direct responsibility for monitoring the driving environment or the physical driving task.

2.2 Route

The route used during the trials connects the centres of Croydon and Bromley.

- Route length was approximately 14 miles (22 km) as a round trip
- Approximately 0.5 miles (0.8 km) ran along a section of the London Trams tramway (east of central Croydon)

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

[3] The SAE define the ADS as "the hardware and software that are collectively capable of performing the entire Dynamic Driving Task (DDT) on a sustained basis, regardless of whether it is limited to a specific Operational Design Domain (ODD); this term is used specifically to describe a Level 3, 4, or 5 driving automation system." (SAE, 2016).

- Urban streets (20-30mph)
- Urban dual carriageway (30mph)
- Shared tramways
- T-junctions
- Signalised junctions and crossroads
- Signalised pedestrian crossings
- Roundabouts

2.2.1 Route use during the trials

During the trial, the journey for any participant or pair of participants was as follows:

- Return journey to/from central Croydon (via Bromley)
- Return journey to/from central Bromley (via Croydon)

A return journey took between 45 minutes to 1 hour to complete and the central locations were less than five minutes' walk to the train stations in Croydon and Bromley, respectively.

2.3 Research design

The research involved two trial phases. These will be described in more detail in Sections 2.3.1 and 2.3.2.

2.3.1 Pilot

The aims of the pilot were primarily as follows:

- To refine trial scheduling, e.g. timings, operations and staff requirements
- To further develop and refine the research questions and data collection materials

As the first trial of its type in the UK, possibly Europe, it was important to establish how to effectively and cohesively run participant trials of this scale. It was also important to plan for the possibility of unforeseen circumstances emerging and any new requirements on staff and/or the trial operation.

2.3.1.1 Research questions (RQs)

In accordance with the aims of the pilot phase, the research questions for this part of the research are:

RQ1. Can trials be consistently and effectively run with invited participants[4]?

[4] Note that participants were invited to the trial from within closed groups (e.g. friends and family and DLG staff). The recruitment process will be elaborated in later subsections.

RQ2. What insights can be gathered relating to participants' experience of the trial vehicle and the types of service models that could be offered?

RQ3. Are the data collection tools fit for purpose? (E.g. are they measuring what we think/ expect them to measure?)

While the answer to RQ1 was derived from a review of operations during the pilot phase, questions 2 and 3 were answered by engaging with participants directly.

2.3.1.2 Participants and recruitment

The pilot phase involved 37 participants in total. These were recruited by Five (via Five staff).

As part of the recruitment drive, Five staff were provided with information about the aims of the study, any exclusions (e.g. children under the age of 18 were not eligible to take part), and instructions on inviting friends and family to take part in the pilot. They were provided with a link to a confidential sign-up form to send to friends and family that enabled Five trial staff to seek consent to contact respondents for the purpose of the research. This process ensured adherence with GDPR requirements as well as providing a basis for ensuring participant data was protected throughout the trials and the later analysis.

Once respondents had consented to be contacted, participants were sent a screener survey and booking form (to select a convenient date and time).

Participants were provided with £50 as reimbursement for travel expenses into London and as an incentive for taking part.

2.3.1.3 Screening criteria

Screening criteria were used to select participants for the trial. These criteria specified that participants must be:

- Over 18 years of age
- A friend or family member of someone who works at Five
- Must not be employed by a Five competitor
- Must not have a direct professional interest in self-driving vehicles or ridesharing services[5]

No journalists were included in the trial sample. Trial participants with specific access requirements were assisted appropriately. These access requirements were not documented nor were they used to group participant responses. No participants were refused a trial experience because of accessibility issues.

Those who were shortlisted, using the criteria listed above, were then assigned a participant number. That number was then used as a unique identifier for accessing all trial-related

[5] The 'interest in AV' screening was necessary during the pilot because participants were not known to the research team and it was necessary to put measures in place to protect intellectual property (IP).

documents and survey materials. Once they had a participant number, they were able to use Five's booking system to book a slot which suited their availability.

2.3.2 Trials

2.3.2.1 Research questions (RQs)

In addition to the questions stated for the pilot phase, additional questions for the formal trials included:

RQ4. What are participants' perceptions of self-driving vehicles and ridesharing in the context of a real-world experience?

RQ5. How can shared self-driving vehicles accommodate the mobility needs of people who commute within the area?

For this part of the research, one of the key elements was that the vehicle was operating in a complex urban environment, travelling along a route familiar to many participants. As such it provided a real-world experience, within the context of their own journeys, on which to base their perceptions.

2.3.2.2 Participants and recruitment

The trial phase involved 73 participants. These were recruited by Five (from the project partner Direct Line Group). Participants were all employees of DLG who were not directly involved in the StreetWise project.

The process followed for recruitment was similar to the pilot phase, and participants were contacted and sent a number of materials, including a filter survey, a pre-survey (gathering information about demographics and journey data - Appendix A) and a booking form to select their preferred time slot.

Participants in this part of the research were not provided any monetary incentive. Instead, as the trial was running during core working hours, DLG allowed participants to take the time to undertake the trial.

2.3.2.3 Screening criteria

The screening criteria were slightly different for the DLG sample; this was mainly due to where the sample was drawn from (i.e. DLG staff). As such, some checks (such as age) were not relevant.

One aspect that was not as strictly applied within this sample was the direct professional interest in self-driving vehicles or ridesharing services; while for the pilot, anyone who had expressed an interest in this area would have been contacted directly to assess that they were not employed by a Five competitor and may have been turned away. For the trial phase, participants were able to take part even if they had expressed a professional interest. This was because the team were satisfied that DLG employees did not constitute a threat to IP.

As with the pilot participants, those who were shortlisted were then assigned a participant number. The number was then used as an identifier for accessing all trial-related documents.

2.3.3 Schedule and procedure

The trials ran on weekdays (Tuesdays and Wednesdays), from 09:30 (first slot) to 15:30 finish (last slot starting at 13:30). On the day of the trial, the participant experience consisted of the following:

1. Arriving at either the Croydon (pilot) or Bromley location (trial) and being greeted by a TRL researcher. At this point participants were:
    a. Provided with a briefing[6] and given the opportunity to ask questions
    b. Provided with a consent form to sign
    c. Escorted to the trial vehicles and introduced to the self-driving technology
2. An experience of the Five self-driving vehicle as a passenger. This included:
    a. A ride lasting around 45-60 minutes
    b. Off-boarding and being escorted to the location where the survey and interview were completed
3. An interview and a short survey with a TRL researcher to discuss their experience

Overall, participants were with the team for up to 2.5 hours.

2.4 Data collection

2.4.1 Measures

Excluding the data collected by the Five vehicles as part of its continuous development process, both phases of the research involved three main methods of data collection: 'real time' self-report measures, two surveys, and a one-to-one interview. All of these can be found in the appendices.

These are discussed in more detail in the sections below.

2.4.1.1 'Real time' self-report measures

The 'real time' self-report measures (Appendix B and Appendix C) were prompted at regular intervals during the journey and answered on a tablet in the vehicle (each rider had their own tablet). These measures were prompted ten times during each journey (five time points

[6] The safety briefing gave details of the safety driver's role and participants were advised to do or not do in terms of interactions during their journey. They were also given a breakdown of the running order of the trial and a reminder of their right to withdraw etc.

in each direction of the two-way journey[7]) and were based on participants rating their perception of four aspects of the self-driving experience at each time point:

- Safety of the self-driving system
- Smoothness of the self-driving system
- Trust in the self-driving system
- Overall opinion of the self-driving system

Responses to these questions were given on a visual analogue scale (VAS; from negative to positive).

The purpose of these measures was to provide information (and supporting data) about how feelings of safety, perceptions of smoothness, trust and overall opinion of the system may have varied within a single journey.

2.4.1.2 Surveys (quantitative and qualitative data)

The quantitative survey was designed to assess aspects relating to both the vehicle automation and ridesharing. The survey was divided into two parts:

- A 'pre' experience survey – completed at the recruitment stage, before participants had seen or experienced the vehicle directly (Appendix A)
- A 'post' experience survey – after their journey in the trial vehicle relating to their experience, and expectations, concerns and a future service model (Appendix D)

The aspects captured within the surveys were derived from the literature and previous real-world trials (e.g. GATEway) so as to continually evolve knowledge in these areas (e.g. trust in the vehicle, willingness to pay and willingness to use).

2.4.1.3 One-to-one interview (qualitative data)

Lastly, the interview (Appendix E) was designed using cognitive interviewing principles[8].

The focus of the interviews was to assess how respondents interpret constructs very frequently used in relation to vehicle automation, albeit in different contexts (and in reference to different Operational Design Domains (ODD), ownership models and applications). As such, we focused on the concepts of 'safety', 'trust' and 'security' and

[7] Time points were approximately equivalent in duration, as were the range and number of specific traffic situations contained within each interval.

[8] Cognitive interviewing (CI) is a method, similar to qualitative interviewing, used to identify problems with research materials (such as questionnaires and topic guides) in order to reduce the errors associated with responses (Willis, 2018). According to Waddington & Bull (2007), cognitive interviewing is designed to facilitate accurate recall of events, and as such it has also been used for interviewing witnesses. In research contexts, cognitive interviews are used to identify apparent problems related to question wording, ordering and format (Willis, 2018). The technique can also be used to ensure survey/interview questions are fit for purpose and to help minimise issues with interpretation of questions or prompts.

explored what aspects participants recalled (either as part of their trial experience, as well as more widely within their lives) when they evaluate these. The interview took up to half hour and was undertaken after the survey was administered.

Note that not all participants undertook an interview. This was due to limited resources within the team.

Participants were either randomly selected (Pilot) or given the opportunity to self-select to fit in with prior work commitments. The latter was necessary for the DLG sample because participants were undertaking the trials during working hours and were not being provided an incentive. As such, flexibility was required to enable the trials to run as smoothly as possible.

2.5 Analysis

2.5.1 Qualitative data

Interview data (as well as any open responses included within the 'pre' and 'post' experience surveys) were analysed using thematic analysis. The team went through responses, generating categories and themes, based on the frequency with which these emerged.

The findings are expressed in terms of 'themes', and these were based on those that emerged most frequently and strongly.

2.5.2 Quantitative data

2.5.2.1 Data checks and cleansing

Before data analysis could be performed, data from each survey was checked to ensure that it was suitable for inclusion in the analysis. These checks were as follows:

1. Checking that participants who completed a pre-trial survey actually took part in the trial, and had completed a corresponding post-trial survey
2. Checking that only approved answers[9] had been given to each question
3. Checking that participants had engaged with the surveys and had not for example given the first answer for every question

2.5.2.2 Survey data

Data was analysed from all three types of survey which participants completed during the trial; before, during and after the trial. The in-vehicle survey was completed separately for

[9] 'Approved answers' are responses given to each question that correspond to the possible answers to the survey. For example, if there were four options to choose from, the checks ensured that every response was either 1, 2, 3 or 4. Or, if the answer was on a sliding scale from 0 to 100, checking that the responses fell within this range.

the two legs of the return journey that participants made in the vehicle (from Bromley to Croydon, and Croydon to Bromley), meaning that there were four sets of survey data to analyse in total.

The pre-trial survey captures some demographics, as well working and commuting patterns and previous experience of Advanced driver assistance systems (ADAS) and ride hailing and ridesharing services. Responses to this survey are presented in Section 3.

The in-vehicle survey captures participants' 'real time' ratings at each of the ten time points (see Section 2.4.1.1), while the post-trial survey identified their opinions of the self-driving system they experienced, as well as self-driving systems and ride hailing and ridesharing services in general, now that they have had an in-vehicle experience.

3 Sample characteristics

This section details the demographics of the final sample, based on responses to the pre-trial survey. It combines data from participants recruited in the pilot phase and those in the DLG sample[10]. Around two-thirds of these participants (65%) were male, and the remaining third (35%) were female.

3.1 Working status and patterns

The majority of the sample were in full-time employment, with only 7% not in work or education, these results can be seen in Figure 2. Of those who were working, the vast majority worked typical daytime office hours, and worked from home to some degree. This can be seen in Figure 3 and Figure 4.

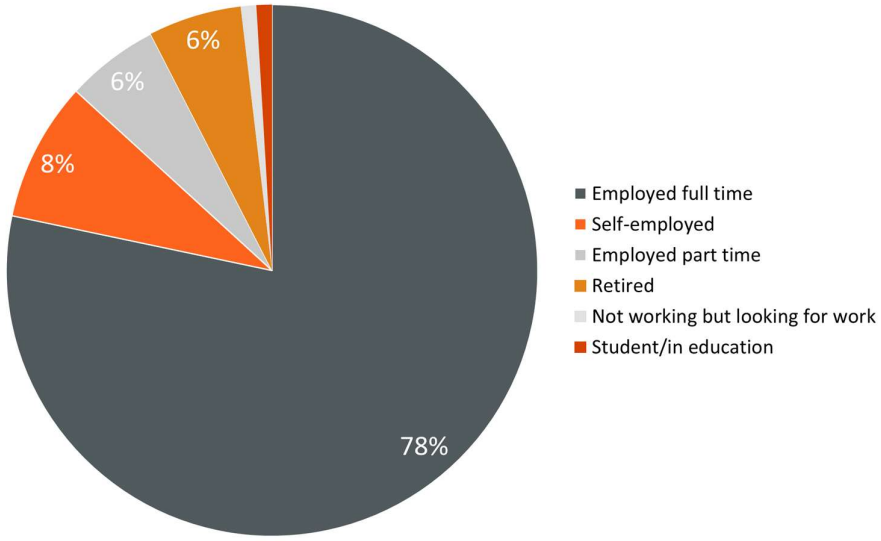

Figure 2: Working status of participants in the sample (n=106)

[10] There were some differences between the two samples in terms of working and commuting patterns, and the level of professional interest in AVs. However, there was not enough evidence to suggest that these differences would have an impact on the patterns of responses to the other survey questions.

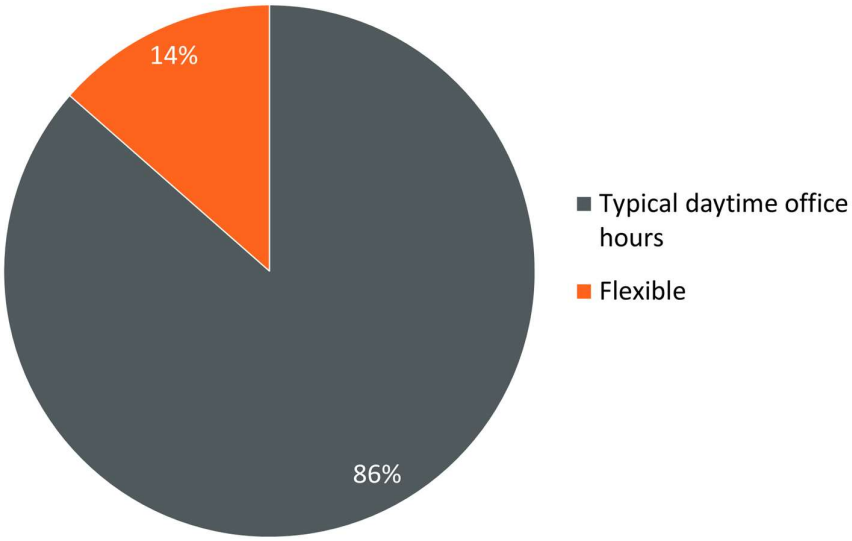

Figure 3: Working hours of participants in the sample (n=96)

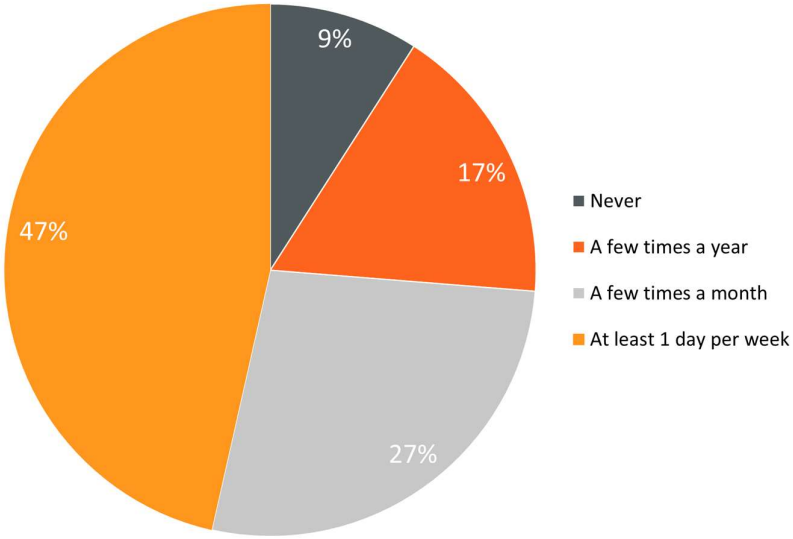

Figure 4: Frequency with which participants in the sample work from home (n=99)

3.2 Commuting patterns

The most common commuting mode among participants was for them to drive their own vehicle to get to work. However, over half of the sample (55%) used public transport, walked or cycled as their most common mode (Figure 5). There was a lot of variability in the length of participants' commute, although for around three quarters of the sample (76%), it was less than 1 hour, these results are shown in Figure 6.

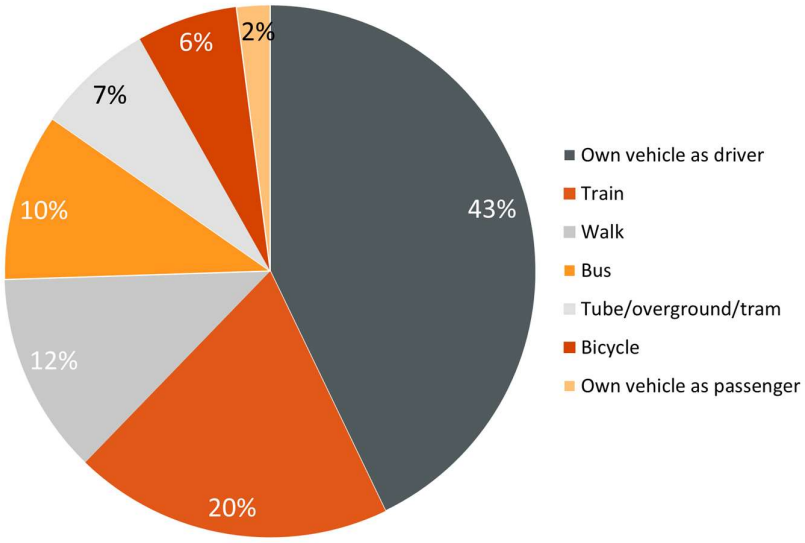

Figure 5: Main mode of transport used for commuting by participants in the sample (n=98)

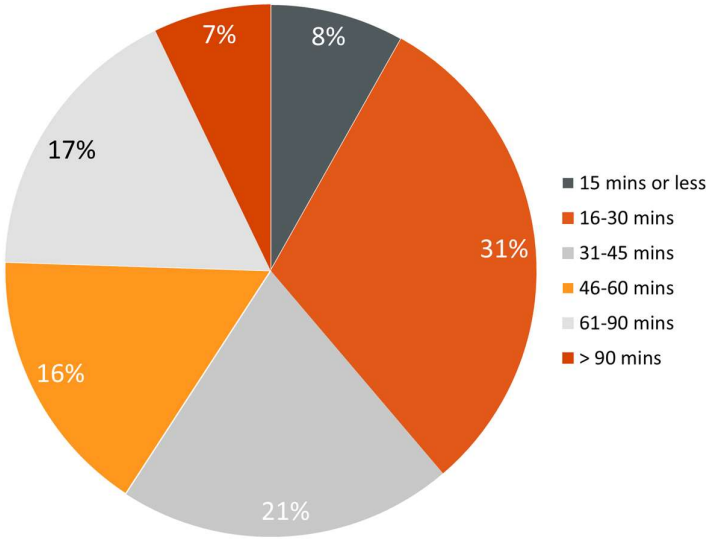

Figure 6: Typical length (in minutes) of a one-way commute for participants in the sample (n=98)

3.3 Experience of ride hailing, ride sharing and ADS

The vast majority of the sample (80%) had some experience of using ride hailing services (Figure 7). However, only a minority had experience of using ride sharing services, such as

UberPool or BlaBlaCar (29%), or other forms of ride sharing, such as commuting to/from work with a colleague (20%), these results are shown in Figure 8 and Figure 9.

Around half of the sample (52%) had some experience of an ADS such as adaptive cruise control, active park assist, autonomous emergency braking or highway driving assist. However, only a third (33%) reported having a professional interest in AVs.

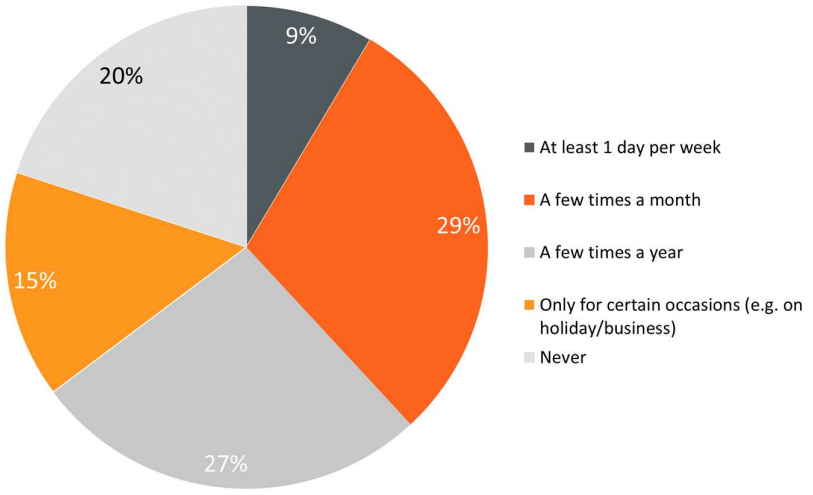

Figure 7: Frequency of use of ride hailing services by participants in the sample (n=105)

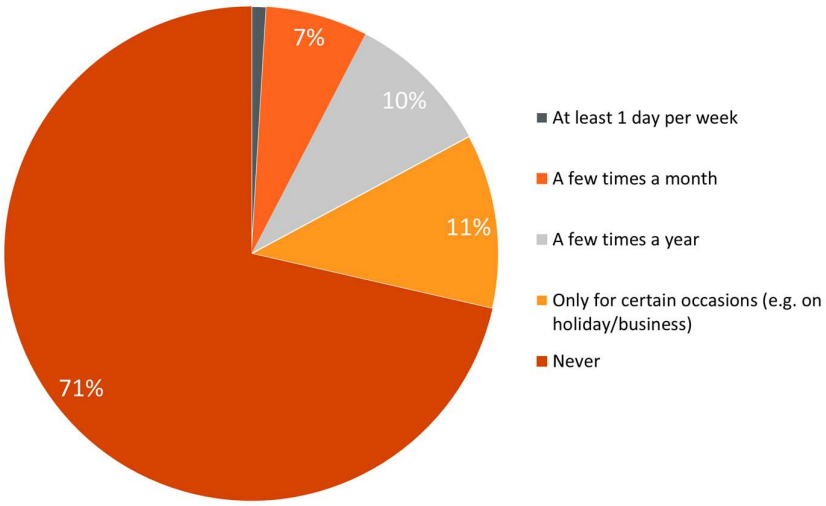

Figure 8: Frequency of use of ride sharing services such as UberPool and BlaBlaCar by participants in the sample (n=105)

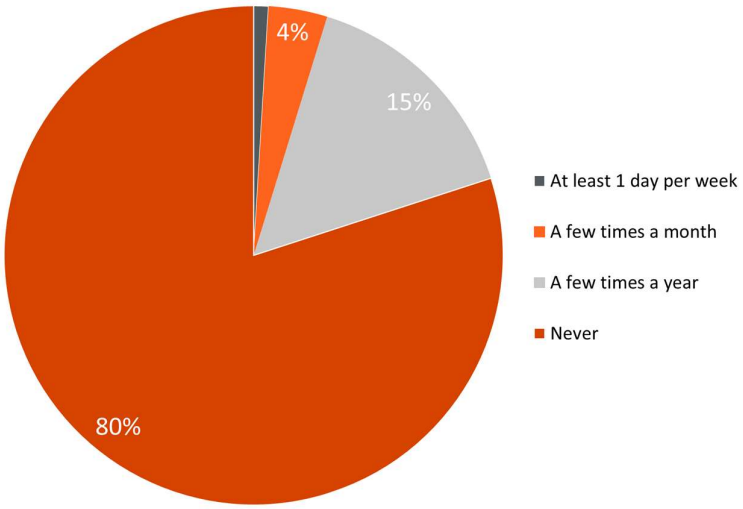

Figure 9: Frequency of use of other forms of ride sharing such as commuting to/from work with a colleague by participants in the sample (n=105)

3.4 Licensure and vehicle ownership

The vast majority of the sample held a full UK driving licence (87%), and of those who did, the vast majority had access to their own vehicle (89%). Of those who owned a vehicle, over half had a petrol car and around two-fifths had a diesel car, with only 4% owning an electric vehicle (results are shown in Figure 10). In addition, the majority (77%) had an annual mileage of less than 10,000 miles (depicted in Figure 11).

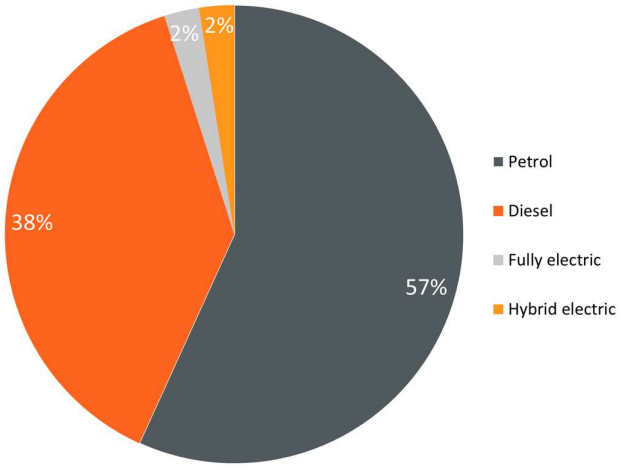

Figure 10: Type of vehicle owned by participants in the sample (n=81)

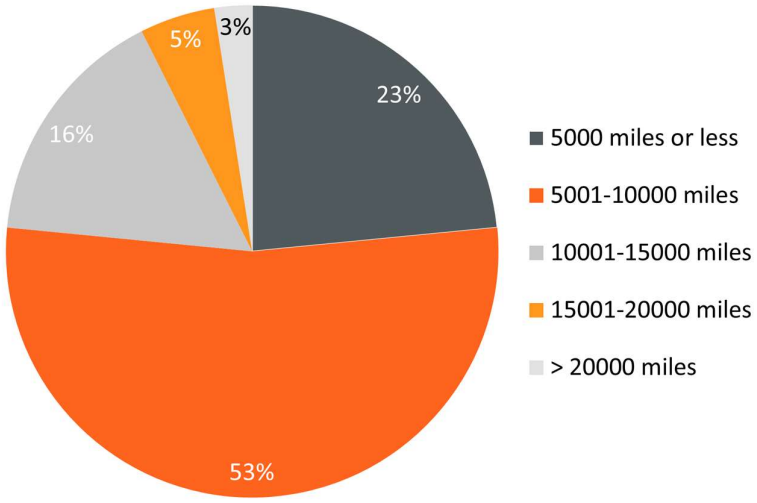

Figure 11: Annual mileage of participants in the sample (n=81)

4 Additional measures

The 'post' experience survey included several previously validated scales because previous literature had identified possible relationships between perceptions of automation (and elements such as willingness to pay and willingness to use) and certain traits, characteristics and/or theories (see Appendix E).

However, the analysis did not yield any significant results relating to these measures and comparison items. Because there is currently insufficient evidence to suggest that there is no relationship between these measures and perceptions of automation and/or ridesharing, more research is required to fully understand the relationship between factors such as personality traits and self-driving vehicle/ ridesharing perceptions and likely uptake.

5 Limitations of the research

As with any research of new technologies, particularly those at the prototype stage, there were limitations in this research.

Firstly, due to legal requirements, the vehicle had to include a safety driver at the wheel. This element was not missed by participants who raised the presence of the safety driver (and often, the engineer) as an element that influenced their perceptions of the journey and journey features. It also meant that safety drivers and engineers had the opportunity to engage with participants one-to-one and provide answers to questions, as well as explain why certain events took place. This will have undoubtably had an effect on participants feelings of safety at the very least and is not necessarily a feature that an unmanned AV would include.

The differences in sampling for the friends and family (pilot) vs DLG samples meant that a large percentage of participants in the DLG sample (46%, compared to 11% in the pilot sample) reported having a professional interest in AVs. However, having considered qualitative responses in the 'post' survey relating to the type of experience/knowledge they may have of the area, it was clear that this was mixed. It ranged from participants who had ridden in other AVs (e.g. in other trials) to others who had simply read information about AVs and the technology more widely. Participant selection was a limitation in general.

Finally, a breakpoint had been planned between the pilot and trials stage; however, the ultimate timeline for the delivery of the trials mean that this breakpoint was not taken. The breakpoint was originally designed to enable the research team to assess the data and protocols in place. While it was possible to review and finalise the trial protocol on an ongoing basis, we were not able to review the data and findings. As such, there was not sufficient time to set out specific research questions to address through this research. Although this resulted in a larger sample to work from, it also meant that findings were less focused on specific questions or issues and more generalised to the experience and overall perceptions of participants. Nevertheless, self-driving vehicle research, particularly in relation to the services they may enable, is an area in much need of new research; particularly research involving direct experience of the technology and service models. Although some theoretical research has been undertaken to assess the cross roads between vehicle automation and ridesharing, it is still poorly understood exactly how this will fit into the existing transport system and how users can be encouraged to use shared services (rather than opt for single occupancy vehicles). As such, this research is an important addition to a growing body of evidence in this area.

5.1 What are the lessons for future research?

For more information on the findings from this trial and how they could be used to supplement future research, see StreetWise trial: Findings report (Fernández-Medina *et al.*, 2020).

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Appendix A Pre-experience questionnaire

Pre-trial questionnaire

Thank you for booking your self-driving experience with FiveAI!

We look forward to welcoming you in London very soon. Before you come for your self-driving experience, please spare 10-15 minutes to complete this survey so we can find out more about you and your current travel preferences.

Completing the survey now will help save time on the day of your self-driving experience with us.

* Please provide your participant ID

* What gender do you identify as?

- ○ Male
- ○ Female
- ○ Non-binary
- ○ Prefer not to say

• Which one of the following best describes you?

- ◯ Employed full time (more than 30 hours per week)
- ◯ Employed part time (30 hours or less per week)
- ◯ Self-employed
- ◯ Homemaker
- ◯ Not working at the moment and not looking for work
- ◯ Not working at the moment but looking for work
- ◯ Retired
- ◯ Student/in education
- ◯ Other/prefer not to say

What are your usual working hours?

- ◯ Typical daytime office hours (e.g. 9am to 5pm)
- ◯ Shift pattern (excluding nights)
- ◯ Shift pattern (including nights)
- ◯ Flexible

How often do you typically work from home?

- ◯ Never (e.g. always office or site-based)
- ◯ Rarely (a few times a year)
- ◯ Occasionally (a few times a month)
- ◯ Regularly (usually at least 1 day per week)

For your commute to/from your usual place of work or study, what mode(s) of transport do you use? Please tick all that apply

- [ ] Own vehicle as a driver
- [ ] Company vehicle as a driver
- [ ] 'Car club' vehicle as a driver
- [ ] Own vehicle as a passenger
- [ ] Company vehicle as a passenger
- [ ] 'Car club' vehicle as a passenger
- [ ] Bus
- [ ] Train (mainline)
- [ ] Tube/overground/tram
- [ ] Taxi (or minicab, Uber, etc)
- [ ] Bicycle
- [ ] Walk (more than 5 minutes)
- [ ] Other

* How long (in minutes) is your commute between home and work/study (one way) on a typical day?

minutes

* Please tell us about the journey you make most often. What is it for?
(For a mixed purpose journey, please give the main reason)

- ◯ Shopping
- ◯ Dropping off or collecting child/children
- ◯ Leisure / socialising
- ◯ Healthcare appointments
- ◯ Other, please specify

For the journey you make most often, what mode(s) of transport do you use? Please tick all that apply

- [ ] Own vehicle as a driver
- [ ] Company vehicle as a driver
- [ ] 'Car club' vehicle as a driver
- [ ] Own vehicle as a passenger
- [ ] Company vehicle as a passenger
- [ ] 'Car club' vehicle as a passenger
- [ ] Bus
- [ ] Train (mainline)
- [ ] Tube/overground/tram
- [ ] Taxi (or minicab, Uber, etc)
- [ ] Bicycle
- [ ] Walk (more than 5 minutes)
- [ ] Other

* How long (in minutes) is this regular journey (one way) on a typical day?

minutes

* How often do you use app-based **ride hailing** services such as Uber?
(**Ride hailing** is a taxi ride that you can access on-demand, via an app. Ride hailing does not involve you sharing a ride with a stranger. It does not include hailing a taxi in person or booking a taxi/minicab by telephone).

- ◯ Regularly (at least 1 day per week)
- ◯ Occasionally (a few times a month)
- ◯ Rarely (a few times a year but not monthly)
- ◯ Only for certain occasions (e.g. on holiday, away on business)
- ◯ Never

Please tell us why you have never used an app-based ride hailing service such as Uber.

- How often do you use **ride sharing** services such as UberPool or BlaBlaCar?
(**Ride sharing**, as opposed to ride hailing, is where you purposefully share a ride to the same or similar destination with a stranger or strangers. This usually lowers the cost of your journey and can also be accessed on-demand, via an app).

- ◯ Regularly (at least 1 day per week)
- ◯ Occasionally (a few times a month)
- ◯ Rarely (a few times a year but not monthly)
- ◯ Only for certain occasions (e.g. on holiday, away on business)
- ◯ Never

- Do you use any other form of ride sharing, such as commuting to/from work with a colleague?

- ◯ Regularly (at least 1 day per week)
- ◯ Occasionally (a few times a month)
- ◯ Rarely (a few times a year but not monthly)
- ◯ Never

Do you currently hold a full (not provisional) driving licence that is valid in the UK?

- ◯ Yes
- ◯ No

- Do you currently own or have unrestricted access to a vehicle?

- ◯ Yes, own/household vehicle
- ◯ Yes, company vehicle
- ◯ No

Is this vehicle:

- ◯ Petrol
- ◯ Diesel
- ◯ Fully electric (i.e. runs on battery power only)
- ◯ Hybrid electric (runs on battery power and petrol/diesel, but cannot be plugged in to charge)
- ◯ Plug-in hybrid electric (i.e. runs on battery power and petrol/diesel, and can be plugged in to charge)
- ◯ Other, please specify

• What is your approximate annual mileage (whether in your own vehicle or in other vehicles if you do not own a vehicle)? If you have not driven in the last year, please put '0'

miles

Do you have experience of using any of the following advanced driver assistance systems on a vehicle?

- ☐ Adaptive cruise control (ACC) – maintains speed and keeps a distance from the vehicle ahead
- ☐ Automatic parking/active park assist – vehicle will park itself
- ☐ Autonomous emergency braking (AEB) – vehicle will stop itself in some types of emergency situation
- ☐ Highway driving assist – vehicle keeps distance from the vehicle ahead, helps stay in lane, change lanes and/or overtake
- ☐ None of these

• Do you have a professional interest in automated/self-driving vehicles? For example, you work/study in the automotive, transport or another related industry and have an interest in the development and deployment of self-driving vehicles beyond personal use.

- ○ Yes
- ○ No

Appendix B In-car questionnaire (Bromley to Croydon)

4.3 In-vehicle survey (Bromley-Croydon)

* Please provide your participant ID

Bromley - Croydon

We'd like to get your responses to this self-driving experience while you are in the vehicle. At regular points in the journey we will ask you the same questions about:

*The safety of the self-driving system
*The smoothness of the self-driving system
*Your level of trust in the system to drive itself
*Your overall opinion of the self-driving system at that particular point in time

Please answer as quickly and as honestly as you can. We are most interested in your immediate reactions to the section of the route that has just been driven.

Please only click 'Next' when prompted by the safety driver or test engineer.

* Time point 1: How would you rate the self-driving experience over this first section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

- Time point 4: How would you rate the self-driving experience over the fourth section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Please only click 'Next' when prompted!

- Time point 5: How would you rate the self-driving experience over this final section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Please only click 'Next' when prompted!

- Time point 2: How would you rate the self-driving experience over the second section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Please only click 'Next' when prompted!

- Time point 3: How would you rate the self-driving experience over the third section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Appendix C In-car questionnaire (Croydon to Bromley)

4.3 In-vehicle Croydon-Bromley

* Please provide your participant ID

Croydon to Bromley

We'd like to get your responses to this self-driving experience while you are in the vehicle. At regular points in the journey we will ask you the same questions about:

*The safety of the self-driving system
*The smoothness of the self-driving system
*Your level of trust in the system to drive itself
*Your overall opinion of the self-driving system at that particular point in time

Please answer as quickly and as honestly as you can. We are most interested in your immediate reactions to the section of the route that has just been driven.

Please only click 'Next' when prompted by the safety driver or test engineer.

* Time point 1: How would you rate the self-driving experience over this first section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Please only click 'Next' when prompted!

- Time point 2: How would you rate the self-driving experience over the second section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Please only click 'Next' when prompted!

- Time point 3: How would you rate the self-driving experience over the third section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

• Time point 4: How would you rate the self-driving experience over the fourth section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Please only click 'Next' when prompted!

• Time point 5: How would you rate the self-driving experience over the final section?

	Negative	Positive
Safety of the self-driving system		
Smoothness of the self-driving system		
Trust in the self-driving system		
Overall opinion of the self-driving system		

Appendix D Post-experience questionnaire

4.4 post-trial questionnaire

Thank you for taking a ride in our self-driving car! We hope you enjoyed the experience.

We'd now like you to answer a few more questions so we can get your feedback on the experience and your opinions on how self-driving technology might influence the future of mobility.

• Please provide your participant ID

• Overall, how would you rate the **safety** of your self-driving experience?

	Not at all safe	Very safe
Safety		

What **3** things most affected your rating of **safety** (either positively or negatively)?

• Overall, how would you rate the **smoothness** of your self-driving experience?

	Not at all smooth	Very smooth
Smoothness		

What **3** things most affected your rating of **smoothness** (either positively or negatively)?

• Overall, how much **trust** did you have in the self-driving system?

	No trust at all	Complete trust
Trust		

What **3** things most affected your feelings of **trust** in the system (either positively or negatively)?

• How would you rate your self-driving experience overall?

	Negative	Positive
Overall		

• What percentage of the total journey do you think was completed in self-driving (fully automated) mode?

0% 100%

Percentage

• How helpful was the in-car tablet for explaining the self-driving system during your experience?

- ◯ Not at all helpful
- ◯ Slightly helpful
- ◯ Helpful
- ◯ Very helpful
- ◯ Extremely helpful

What did you like about the in-car tablet?

What did you dislike/what could be improved on the in-car tablet?

• How would you rate today's self-driving experience against your expectations?

Much worse than I expected Much better than I expected

Expectations

• Why was the experience better or worse than you expected?

• What were your expectations of today's experience based on?

• How concerned are you about the following in relation to self-driving vehicles like the one you have experienced in this trial?

	Not at all concerned	Slightly concerned	Concerned	Very concerned	Extremely concerned
Passenger safety	○	○	○	○	○
Driving in poor weather	○	○	○	○	○
Speed of the vehicle	○	○	○	○	○
Reliability of the vehicle	○	○	○	○	○
Interactions with human-driven vehicles	○	○	○	○	○
Interactions with pedestrians	○	○	○	○	○
Interactions with cyclists	○	○	○	○	○

• Currently, how positive or negative do you feel about:

	Very negative	Negative	Neither positive nor negative	Positive	Very positive
Ride sharing services in general (not just self-driving examples)	○	○	○	○	○
The impact on mobility of this type of self-driving ride sharing service in your area	○	○	○	○	○
The impact of this type of self-driving ride sharing service on your regular commute/journeys	○	○	○	○	○

Please watch the video before answering the next question

• Based on the video you just saw, if this type of self-driving vehicle offered a ride sharing service in your area, how likely would you be to use it for your daily commute (or regular journey if you do not work/commute)?

	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely
Likelihood	○	○	○	○	○

- Imagine the self-driving technology you experienced today being used in a larger, multi-passenger vehicle like the concept you just saw in the video.

  For this type of self-driving service, please state how much you agree or disagree with the following statements.

  (Note - if you do not work/commute, please answer with regard to the journey you make most often)

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
This type of self-driving service is compatible with my daily commute	○	○	○	○	○
This type of self-driving service fits well with the way I like to travel to and from work	○	○	○	○	○
Using this type of self-driving service for my commute would require me to make substantial changes to my current travel patterns	○	○	○	○	○
It would be difficult to incorporate this type of self-driving service into my daily commute	○	○	○	○	○
Overall, I believe that it would be complicated to incorporate this type of self-driving service into my daily commute	○	○	○	○	○
I believe that I could try out this type of self-driving service on an occasional basis before it is widely deployed	○	○	○	○	○
I will not see any significant improvements to my daily commute if this type of self-driving service is widely deployed	○	○	○	○	○
Using this type of self-driving service will enhance my effectiveness when travelling to and from my place of work	○	○	○	○	○
This type of self-driving service will increase the quality of transport in my area	○	○	○	○	○
Using this type of self-driving service for my daily commute will have no effect on my personal mobility	○	○	○	○	○

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Using this type of self-driving service for my daily commute would require more effort than my current transport options	○	○	○	○	○
Even if the government did not encourage the use of automated vehicles, I would like to use this type of self-driving service for my daily commute	○	○	○	○	○
Overall, this type of self-driving service would be advantageous for my daily commute	○	○	○	○	○

- Personality traits often help to explain differences in people's behaviour and attitudes, especially towards the introduction of new technology and services. To help us understand the different personality types taking part in this trial, here are a number of characteristics that may or may not apply to you. Please state how much you agree or disagree with the following.

I am someone who...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Tends to be quiet	○	○	○	○	○
Is compassionate, has a soft heart	○	○	○	○	○
Tends to be disorganised	○	○	○	○	○
Worries a lot	○	○	○	○	○
Is fascinated by art, music, or literature.	○	○	○	○	○
Is dominant, acts as a leader	○	○	○	○	○
Is sometimes rude to others	○	○	○	○	○
Has difficulty getting started on tasks	○	○	○	○	○
Tends to feel depressed, blue	○	○	○	○	○
Has little interest in abstract ideas	○	○	○	○	○
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Is full of energy	○	○	○	○	○
Assumes the best about people	○	○	○	○	○
Is reliable, can always be counted on	○	○	○	○	○
Is emotionally stable, not easily upset	○	○	○	○	○
Is original, comes up with new ideas	○	○	○	○	○

Appendix E Cognitive interview

Cognitive interview-style assessment (30 minutes)

During the next half hour, I'd like to talk to you about some specific aspects of your journey. I will ask you some general questions and I'd like to feel free to expand on your answer as much as you want. I may also ask follow on questions or for clarifications – this is, to make sure I have fully understood your perspective.

The purpose of this interview is to understand how you arrive at a certain answer or opinion, so I may remain quiet to give you time to talk through your answers. I may move the discussion on if we start to run out of time an any particular question.

I may also ask you to explain why you have a certain answer - this is only so I can understand more about your reasoning, it is not meant as a challenge or judgement in any way.

Do you have any questions? (any questions about the purpose of the research should probably be discussed after the interview)

Are you happy to proceed? If so, I will also start the audio recording now.

Introduction

Participant number:

Date:

Researcher:

Time/ session:

Journey start/end location and approximate duration:

Any noteworthy comments regarding today's journey:

Safety

How safe did you feel during your journey in the trial vehicle?

I want you to think back to your answer, what was the first thing that came to your mind? (a particular event/ location/ part of the experience)

Why do you think that came to mind first?

Without too much thought, tell me the first thing/ person/ event that comes to mind when you think about feeling safe?

Why do you think that thing/ person/ event came to your mind? What is it about it that defines safety for you?

What does 'safety' mean to you?

Why do you think you've arrived at this definition?

Security

How secure would you say you felt during your journey in the trial vehicle?

I want you to think back to your answer, what was the first thing that came to your mind? (a particular event/ location/ part of the experience)

Why do you think you thought about that specifically?

Without too much thought, tell me the first thing/ person/ event that comes to mind when you think about feeling security?

Why do you think that thing/ person/ event came to your mind? What is it about it that defines feeling security for you?

What do you think 'security' means to you?

Why do you think it's different/ the same to 'safety'?

Why do you think you've arrived at this definition?

Trust

Would you say you felt trust in the technology you've experienced today?

I want you to think back to your answer, what was the first thing that came to your mind? (the vehicle/ a particular event/ location/ part of the experience)

Why do you think you thought about that specifically?

Without too much thought, tell me the first thing or person that comes to mind when you think about trust?

Why do you think that thing/ person came to your mind? What is it about it that defines trust for you?

What do you think 'trust' means to you?

Why do you think it's different/ the same to 'safety'?

Why do you think you've arrived at this definition?

The future

How do you see yourself using shared self-driving vehicles in the future?

Now you've had an experience in a self-driving vehicle, what role do you think they could have in your future mobility?

What factors might make it more/less likely for you to use shared self-driving vehicles in the future?

What do you think this industry should focus on as a priority to win over consumers in the future?

End

That's all the questions I had to go through with you today. Thank you for your time.

Any additional questions/ any questions that were not answered at the start.

Escort participant back to start point.

Appendix F Additional measures

Personality

The survey included the Big Five Inventory-2 (BFI-2; Soto and John, 2017). The BFI-2-XS includes 15 items and, despite its condensed form, was found to retain the full measure's reliability and validity.

This measure was included given that some previous research suggests relationships between personality traits and both attitudes to AV adoption and travel mode choice (Charness *et al.*, 2018; Johansson *et al.*, 2006).

However, analysis undertaken using this measure failed to yield any significant results suggesting that, at least with the sample and measures included in this research, personality traits do not correlate to attitudes toward AVs, ridesharing and/ or the journey experience during the trial.

Diffusion of Innovation

The Diffusion of Innovation (DoI) theory (Rogers, 1962) is often used in the transport industry in relation to new technologies such as electric vehicles, although what is most frequently used in this type of research are the five adopter categories (e.g. innovators, early adopters, early majority, late majority, and laggards) that are believed to influence uptake. The theory is one of the many innovation uptake models that theorises about the factors that influence the adoption (and diffusion within a social structure, hence the name of the theory) of innovations. It proposes five perceived attributes of an innovation:

- **Relative advantage:** the degree to which an innovation is believed to be better than the idea it replaces
- **Compatibility:** the degree to which an innovation is believed to be consistent with individuals' existing values, past experiences and needs
- **Complexity:** the degree to which an innovation is perceived as difficult to understand and use
- **Trialability:** the degree to which an innovation may be experimented with on a limited basis
- **Observability:** the degree to which the results of an innovation are visible to others

Some research has attempted to measure how well new approaches or 'innovations' stand up to these factors (and, therefore, how likely are they to achieve uptake/ acceptance). One such study was by Pankratz *et al.* (2002): the authors created a bespoke scale to assess the perceived attributes of a particular innovation, a new federal policy aimed at the education sector in the United States.

The scale developed by Pankratz *et al.* (2002) was adapted by TRL for use within the AV trials, in order to assess the perceived attributes of a shared AV service. A factor analysis yielded a three-factor model, though factor loadings were mixed with items designed to

measure relative advantage and compatibility being spread across factors. Table 1 provides a breakdown of factor loadings and items.

Table 1: Factor loadings for DoI items

Factor	Items with strong loading (> 0.5)	Main DoI factor represented
Factor 1	Relative advantage, compatibility and complexity	Complexity
Factor 2	Observability, relative advantage, compatibility	Relative advantage, compatibility
Factor 3	Trialability	Trialability

As such, the model was not able to identify the five factors contained within the DoI. Future research is required to develop a scale that can more accurately assess the perceived attributes of AVs and AV rideshare services.

StreetWise trials: Technical report

The StreetWise project investigated participants' perceptions of demonstration journeys in a Five self-driving vehicle. Participants gave 'real time' insights on their experience, and took part in surveys and interviews about aspects of their journey and their thoughts on using this type of vehicle in their future mobility. This report describes the technical method, such as aspects of the cars and the sensors, the route and safety driver training. It also describes the research design, analysis and the sample characteristics. For more detailed findings, see Streetwise trials findings report.

Other titles from this subject area

PPR851	Bridging the final metres: Public feedback on a last mile driverless delivery service. S Tong. 2017
PPR858	GATEway: Public perceptions of a last-mile driverless shuttle. K Fernández-Medina and R Jenkins. 2017
PPR964	StreetWise trials: Findings report. K Fernández Medina, A Holcombe, M Collins and A Wardle. 2020

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