Perceptions of, and behaviours around, driverless vehicles

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Table of Contents

Executive Summary

Original research on perceptions of, and behaviours around, driverless or automated vehicles (AVs) was conducted. Perceptions were investigated via two online surveys designed to capture different road user perspectives before ("pre-trial") and during ("Trial 1") a research trial where AVs operated in a public setting. Additionally, behaviours around these AVs during crossing and passing interactions were observed. As the trial site was a shared space, baseline road user behaviours were observed also. Altogether, the research was designed to provide insight into the potential for AVs and other road users, particularly pedestrians, to safely intermix in a shared environment.

Methods

A total of 916 members of the UK public (49% male, 51% female, mean age 40.91 years) completed the pre-trial survey. These participants provided perceived risk ratings for AVs and other modes of transport from the perspective of a pedestrian as well as a passenger, plus stated their general attitudes towards the prospect of AVs being on the public roads in the future.

A further 65 members of the public (55% male, 45% female, mean age 36.72 years) completed the Trial 1 survey. They too provided perceived risk ratings, specifically for the AV pods they directly interacted with, either as a passenger (n = 57), pedestrian (n =7) or cyclist (n = 1), during the research trial. They also stated their general attitudes towards the prospect of AVs.

In total, 330 members of the public (69% male, 31% female, mode age category "adult", comprising pedestrians, joggers, and cyclists) were observed directly interacting with the AV pods at the trial site, either while crossing (n = 66), or while passing or being passed in a shared lane (n = 264). A further 238 road users (again, pedestrians, joggers, cyclists; 56% male, 44% female, mode age category "adult") were observed for their use of the shared lane when pods were not present (i.e. baseline behaviours).

Results

The survey data revealed that:

- AVs were perceived as posing a low risk ("somewhat low risk" for pre-trial sample, "extremely low risk" for Trial 1 sample).

- There was an increase in positivity (43% -> 84%) and a lowering of uncertainty (46% -> 11%) when comparing Trial 1 with pre-trial attitudes towards AVs.

The observational data showed that road users tended to:

- Cross in front of an approaching AV, rather than behind it or wait.

- Travel in the middle of/spread across the shared lane in the absence of AVs.

- Keep or move to the more open Thames side (i.e. yield) rather than remain in place when passing or being passed by the AVs.

Implications of the Findings

The findings appear to indicate that small road-based passenger AVs and other road users such as pedestrians may be able to safely intermix in a shared environment. However, effort is required to ensure vulnerable road users' views receive appropriate attention. Future research trials should also bear in mind the influence of setting, vehicle type/speed, and familiarisation over time on behaviours.

1 Introduction

1.1 Background

While fully automated vehicles (AVs) – also known as "driverless", "autonomous", "self-driving" vehicles – have been operating in the UK and other countries for a number of years, these AVs run in enclosed, exclusive spaces. That is, they run either on tracks (e.g. the Docklands Light Railway, DLR) or on a conventional but bounded road surface (e.g. Heathrow pods), to which no other form of transport or road user has access. Now, work is focusing on introducing AVs to the public roads, where the AVs and other road user groups will intermix. This will represent a revolution in passenger transport.

One of the main motivating factors for the move to bring AVs to public roads is the desire to reduce the number of road traffic collision casualties. In the year 2015, a total of 186189 people were injured in road traffic collisions in Britain; of this total, 22144 people were seriously injured and a further 1730 were fatally injured (Department for Transport, 2016). The most vulnerable road user groups – i.e. those with the highest casualty rate per mile travelled – were, as in previous years, motorcyclists, bicyclists and pedestrians (Department for Transport, 2016). Various factors contributed to these collisions, including issues with vehicles (e.g. defective tyres) and the environment (e.g. weather conditions leading to a slippery road surface and/or reduced vision). However, the main factors were attributable to the human operators of the vehicles involved: i.e. the driver/rider's error or reaction (e.g. resulting in a loss of control), injudicious action (e.g. exceeding the speed limit), behaviour or inexperience (e.g. being careless, reckless, or in a hurry), and impairment or distraction (e.g. via the consumption of alcohol) (Department for Transport, 2016). Logic would suggest that, if these human factors were to be eliminated or rendered ineffective, then the number of road traffic collisions, and consequently the number of associated casualties, would reduce substantially. Therefore, vehicles able to operate without human control are seen as a means to improve road safety, especially to the benefit of vulnerable road users.

1.2 Perceptions of AVs

While it is possible to make a small passenger AV that is *objectively* safer than its human-operated equivalent – i.e. equipped with state-of-the-art technology that can react quickly and in a controlled fashion to hazards, and programmed to behave in a more careful and legal manner – this is unlikely to be sufficient. For such a vehicle to be accepted on public roads, it will also need to be *perceived* as safe. Subjective risk is known to determine public acceptance of technologies, and such risk perceptions are likely to be influenced not only by knowledge and expert opinion imparted in sources such as academic publications and media articles but also by direct personal experiences with technologies, evoking both a cognitive evaluation and an emotional reaction (Gupta, Fischer & Frewer, 2012). Other determinants of public acceptance include attitudes and individual differences (Gupta, Fischer & Frewer, 2012), and each of these various determinants are believed to be associated with socio-demographic factors such as gender and age (Rhodes & Pivik, 2011; Venkatesh, Morris, Davis & Davis, 2003; Venkatesh, Thong & Xu, 2012).

1.2.1 Public Surveys

Research into what members of the public think and feel about AVs has grown in the past five years. Such research has typically been conducted using online questionnaire surveys (e.g. Bansal, Kockelman & Singh, 2016; Kyriakidis, Happee & de Winter, 2015; Schoettle & Sivak, 2014; Smith, 2016), and responses have revealed that while many participants recognise the road safety benefits AVs could bring (see the UK survey reported by Smith, 2016, for an exception), many also had a number of concerns. These concerns related to various issues, with potential system or equipment failures more prominently featuring. Gender differences were commonly and consistently found, with males appearing more open to AVs than females (Bansal, Kockelman & Singh, 2016; Kyriakidis, Happee & de Winter, 2015; Schoettle & Sivak, 2014; Smith, 2016). Findings on associations with age were more mixed (Bansal, Kockelman & Singh, 2016; Kyriakidis, Happee & de Winter, 2015; Schoettle & Sivak, 2014).

One very noticeable aspect of public surveys to date is the focus on buying and/or using AVs. Thus, while these surveys provide a good indication of people's acceptance from a passenger perspective, they overlook the perspectives of other road users, such as pedestrians. As vulnerable road users, people travelling on foot (and on bicycles) would theoretically stand to benefit most, safety-wise, from other people's adoption of AVs as a means of transport. So it could be hypothesised that pedestrians would perceive AVs as posing lower risk and would display more positive attitudes towards AVs. Thus, the level of general public acceptance indicated in research to date could be an underestimation.

1.3 Behaviours Around AVs

While other road users' perceptions are important, their *behaviours* around AVs would be just as, if not more important, to the successful integration of AVs into public environments. Pedestrians not only become victims of road traffic collisions, they also contribute to the occurrence of these incidents, for various reasons including: failing to look properly; failing to judge a vehicle's path or speed; being careless, reckless, or in a hurry; and being impaired by alcohol (Department for Transport, 2016). If pedestrians were to trust in the expected ability of AVs to better react to hazards, they could become complacent with respect to their own safety when around such vehicles. Consequently, there could be a rise in risky pedestrian behaviours, thereby leading to more unavoidable collisions and undermining AVs' potential for road safety benefits.

1.3.1 Behaviours During Crossing Interactions

The most common place where pedestrians and road vehicles directly interact are at pedestrian crossing points. These can be designated places to cross (indicated by markings painted on the ground and/or the presence of traffic signals) or non-designated (unmarked and no signals, but where there is a tendency for pedestrians to cross due to factors such as the presence of a T-junction, the presence and location of attractions, volume of traffic, road width, and so forth; Shurbutt, 2013). At non-designated crossing points, there is a greater onus on pedestrians to behave in ways that ensure their own safety. One example of a safer crossing behaviour would be choosing to wait for an approaching vehicle to pass before crossing. A less safe crossing choice would be starting to cross as the vehicle approaches but taking a curved route round the back of the vehicle. The riskiest crossing choice would be to cross in front of the approaching vehicle. It could be hypothesised that pedestrians would be more likely to choose to cross in front of an AV rather than cross behind it or wait, if they assumed it would be programmed to avoid collisions.

Moving at a faster speed when crossing in front of an approaching vehicle could lessen the risk of a collision. In fact, research has found that, when crossing roads in general, pedestrians travel at a faster average speed than normal (Ishaque & Noland, 2008). UK studies have noted average crossing speeds of between 1.11 and 1.16 m/s for older adults and between 1.32 and 1.57 m/s for adults younger than that (Ishaque & Noland, 2008). A study in the USA examining jaywalkers recorded an average crossing speed of approximately 1.58 m/s (Zheng, Chase, Elefteriadou, Schroeder & Sisiopiku, 2015); no details about the jaywalkers' estimated ages were reported. In addition to younger adults crossing relatively faster, research has shown males and lone pedestrians tend to cross faster than females and pedestrians in groups (Ishaque & Noland, 2008). However, moving faster when crossing could be considered objectively risky behaviour as greater travel speeds increase the probability of slips, trips and falls (Chang, Leclercq, Lockhart & Haslam, 2016). Faster speeds would also suggest that pedestrians recognised on a subjective level that their crossing behaviour was risky. Another observable sign of perceived risk would include hesitation (i.e. stepping out then stopping or even stepping backwards; Zhuang & Wu, 2011). In contrast, a failure to perceive risk could be denoted and observed through pedestrians showing signs of inattention in the vicinity of an approaching vehicle (e.g. looking down at their phones or towards their companions, engrossed in conversation, rather than looking left and right; Zhuang & Wu, 2011).

Gaps play an important role in pedestrian behaviour at crossing points. Researchers typically refer to the Highway Capacity Manual's definition of a gap, which itself refers to a road where the flow of vehicular traffic is continuous, i.e. a gap is "the elapsed time interval (time headway) between arrivals of two successive vehicles in the major stream at the same reference point" (as cited in Kaparias, Hirani, Bell & Mount, 2016). Thus, for a pedestrian at a crossing point on a busy road, the gap of interest would be the time between the first vehicle as it enters the crossing (reference) point and the next vehicle behind it. The pedestrian could accept that gap, in other words choose to start crossing the road, or reject that gap and wait for a longer one between successive vehicles. On a less busy road, the reference point would remain the same (the crossing point) but the gap of interest would be the one between that point and the first/only approaching vehicle. Again, a pedestrian could choose to accept or reject that gap. Gap acceptance varies from person to person, and can be influenced by a number of factors; however, research suggests that it is rare for a gap of less than 2 seconds to be accepted, and that, on average, accepted gaps tend to be at least 3 seconds long (Chandra, Rastogi & Das, 2014).

While gap acceptance is subjective, gaps can also be considered objectively. That is, it is possible to calculate the time required for the pedestrian to complete their crossing action before the approaching vehicle enters the crossing point, thus avoiding a collision. Consider the following example (using the aforementioned average crossing speeds from the literature and vehicle speed and lane measurements from the research trial described later in this report):

- A younger adult pedestrian, travelling at an average crossing speed of 1.32-1.57 or 1.58 m/s, would take 2.1-2.5 seconds to cross a vehicle lane that was 3.3 metres wide
- An older adult pedestrian, travelling at an average crossing speed of 1.11-1.16 m/s, would take 2.8-3.0 seconds to complete crossing the lane
- For the average pedestrian then, the required time to cross would range from 2.5 seconds to 2.8 seconds; rounding to the nearest whole unit, it

would appear that a pedestrian would need at least 3 seconds to complete crossing the lane

- Thus, if a pedestrian chose to start crossing the lane when an approaching vehicle was fewer than 3 seconds away from the crossing point, this could be judged to be risky behaviour

To a direct observer, this gap would be more easily gauged by distance than time, if the vehicle's speed was a known quantity:

- A vehicle travelling at a low, constant speed of 4.17 m/s (i.e. 15 km/h or under 10 mph) would cover a distance of 8.7-10.4 metres in 2.1-2.5 seconds
- The same vehicle would cover a distance of 11.6-12.5 metres in 2.8-3.0 seconds
- The average distance covered by the vehicle then would range from 10.2 metres to 11.5 metres; rounding to the nearest whole unit, it would appear that the vehicle could cover a distance of at least 10 metres in the time required for a pedestrian to complete their crossing action
- So, if a pedestrian chose to start crossing the lane when an approaching vehicle was fewer than 10 metres away from the crossing point, this could be judged to be risky behaviour

In the above example, the (time) gap is very similar to the typical minimum accepted gap reported in the literature described earlier (i.e. both approximately 3 seconds long). So, at first glance, one might predict that most pedestrians would not tend to cross in front of an AV moving at such a speed. However, as mentioned earlier, gap acceptance is subjective. Therefore, if pedestrians were to *perceive* themselves to be safer and in a relatively more dominant position around AVs in general than when around conventional cars, then it could be hypothesised that they would accept shorter gaps than normal during an interaction with an approaching AV.

One UK study (Kaparias, Hirani, Bell & Mount, 2016) examined crossing behaviours in a shared space – i.e. an area designed to be more accommodating towards pedestrians, by reducing the speed of motor vehicles and taking other measures to allow pedestrians more free movement within the space (Department for Transport, 2011). The results showed that, following redevelopment of the area into a shared space, vehicle speeds did decrease significantly, although the gap between vehicles did not, remaining between 3 to 4 seconds on average at locations 1 and 2. Interestingly, pedestrian crossing speeds also decreased significantly (from a mean speed of 0.83 m/s at location 1 and 0.78 m/s at location 2 to a mean speed of 0.72 m/s at locations 1 and 2). Moreover, pedestrians accepted significantly shorter gaps once the area became shared, although these gaps were always more than 3 seconds (gaps tended to be greater than 5 seconds at locations 1 and 2 before the redevelopment, and greater than 4 seconds at those locations after). The authors concluded that the change to shared space now gave pedestrians, particularly those who were older or travelling in groups, more confidence when engaging in crossing interactions with vehicles. Their findings also support the idea that factors which embolden pedestrians may influence their crossing behaviours.

1.3.2 Behaviours During Passing Interactions

As an aim of shared space is to give pedestrians the opportunity to move freely within an area, this means crossings will not be the only situation where pedestrians and vehicles directly interact. Instead, passing scenarios (where one type of road user attempts to pass the other) should become more interactive. That is, unlike in a more conventional road space where pedestrians are largely confined to the pavements on either side, and thus they and vehicles independently pass one another by, shared spaces should elicit more situations where pedestrians and vehicles encounter one another, either in a head-on approach or from behind, moving in the same path, and thus face a “conflict”. As shared spaces may lower the perceived dominance of motor vehicles and embolden pedestrians, it is possible that pedestrians may be unwilling to yield in such scenarios and remain in place, forcing vehicles to change path in order to complete the pass. It could be hypothesised that, if pedestrians assumed AVs were programmed to avoid a collision, then instances of them remaining in place and not yielding could be more commonplace in interactions with such vehicles.

One question is whether pedestrians do actually use shared spaces in the expected way, i.e. not constrain themselves to the sides but instead spread out across the areas and directly interact with other road users. A study in New Zealand (cited in Karndacharuk, Wilson & Dunn, 2014), where trajectory analysis was undertaken, found that pedestrians did move more freely within the shared space. In contrast, a UK study (Moody & Melia, 2014) found that pedestrians tended to avoid part of the shared space where road user interactions could be most complex and diverted from their desired paths to instead use informal crossing points that had been put in place. Moreover, this study found that in situations where the paths of pedestrians and vehicles conflicted, pedestrians most often (72% of cases) were first to yield. On-street interviews revealed that 78% of those pedestrians surveyed felt they had less, rather than more or equal, priority over vehicles and 80% felt safer when the area was not shared.

It should be noted that the vehicle speeds in the New Zealand and UK shared space studies were quite different; both locations had set speed limits for motorists, 10 km/h (i.e. 2.78 m/s or just over 6 mph) in the former and 20 mph (i.e. 8.94 m/s or approximately 32 km/h) in the latter. It appeared that motorists in the New Zealand study often exceeded the speed limit, with the mean vehicle speed reported to be approximately 16 km/h (4.44 m/s or approximately 10 mph; cited in Karndacharuk, Wilson & Dunn, 2014), although this remains quite slow. No measurements were taken in the UK study to confirm vehicle speeds (Moody & Melia, 2014) but a separate piece of qualitative research on shared space activities at same site included reports from participants that other motorists sometimes exceeded the speed limit while they kept within it (Dickens, Healy, Plews & Uthayakumar, 2010). So it is possible that, on average, the vehicle speed at the UK site could have been twice that experienced at the New Zealand site. Compared to average walking (not crossing) speeds observed in the UK – which may range between 1.44 m/s (i.e. approximately 5 km/h or over 3 mph, during the middle of the day) and 1.50-1.51 m/s (the same, during early morning and evening; Willis, Gjersoe, Havard, Kerridge & Kukla, 2004) – this vehicle speed could have seemed quite intimidating for pedestrians. Therefore, the behaviours and perceptions reported in the UK study may not be generalisable to other studies in shared spaces with vehicles moving at slower speeds, such as AVs. Given aspects (including but not limited to vehicle speed and markings/signage) of one shared space can vary greatly from another, it would seem prudent not to automatically assume that if a space is shared, pedestrians will move freely. Instead, data on pedestrian movements should be collected at any site of study to establish a baseline of behaviours for that site. This is especially necessary since research on shared space appears to be limited to date.

The discussion thus far has focused on passing interactions between pedestrians and motorised vehicles. However, another road user group may use shared spaces: cyclists. In terms of orientation, it might be expected that cyclists follow the general rule for drivers and riders in the UK, i.e. keep to the left, except for when overtaking (Rule 160 in the Highway Code; Department for Transport, 2007). Thus, it could be hypothesised that, in a head-on approach with an AV, cyclists will keep left and pass by without any conflict and, where cyclists approach an AV from behind, they will move to the right if attempting to pass. However, this rule is for spaces where vehicles are dominant. In another UK rule, specifically about shared spaces for pedestrians and cyclists, cyclists are warned that if the two road user groups are segregated in these spaces (e.g. there is a line separating the two), they must keep to the cyclist side (Rule 62 of the Highway Code; Department for Transport, 2007). Thus, in areas designed to be more accommodating to pedestrians, cyclists may actually be used to conducting all their passing interactions – i.e. passing and being passed – on just the left or just the right of a shared space, depending on which side has been assigned to them. While this rule also acknowledges that some shared spaces are unsegregated, it does not give guidance for what cyclists should do in such cases. Thus, the orientation from segregated shared spaces could carry over into unsegregated spaces, leading to cyclists on both the left and right sides depending on what they may be used to.

A study (Atkins, 2012) of spaces shared by cyclists and pedestrians in the UK indicated no adherence to the keep left, overtake on the right rule, instead reporting that cyclists "tended to weave around pedestrians" in unsegregated areas. This study also looked at pedestrian behaviour in segregated spaces shared with cyclists and found that there was a tendency for pedestrians to spread out across the space into the cycle lane when in larger groups. An Australian study (Hatfield & Prabhakharan, 2016) found contrasting results, with the majority (more than 80% each) of cyclists and pedestrians tending to orient to the left of the shared space when not involved in passing interactions. This tendency was greater for cyclists but less frequently observed when they were travelling in a group. Group size, however, was not significantly associated with orientation for pedestrians. During passing interactions, almost all pedestrians (97%) who were travelling on the left when approached from behind by a cyclist kept to the left. A similarly high percentage (91%) of those travelling on the right kept to the right while a lower yet still high percentage (87%) of pedestrians travelling in the middle of the space remained in place when being passed. Similar results was found for head-on approaches (98%, 100% and 80%, respectively). It should be noted that in the part of Australia where data collection took place, cyclists are required by law to keep left in shared spaces with pedestrians except where impractical, so the results of the study appear to reflect prescribed behaviour; however, pedestrians are not required by law to do the same yet most did so.

The UK study of shared cyclist/pedestrian space (Atkins, 2012) found average cycling speeds ranging from 9.2 mph (i.e. 4.11 m/s or approximately 15 km/h) to 11.6 mph (i.e. 5.9 m/s or approximately 19 km/h) on weekdays in unsegregated shared spaces. In the Australian study (Hatfield & Prabhakharan, 2016), where data was collected on weekdays and weekends, most cyclists were estimated to be travelling between 10 and 20 km/h (i.e. 2.78-5.56 m/s or approximately 6-12 mph) in unsegregated space. Furthermore, only 6% of cyclists were observed to change their speed and slow when passing pedestrians. Thus, cyclists may appear to be more dominant in passing interactions. However, with an AV moving at a similar to speed to cyclists, no obvious prediction can be made as to cyclists' orientation and speed when encountering one in a passing interaction in a shared space.

During direct interactions with other road users – whether passing or crossing interactions – pedestrians and cyclists may engage in attempts to communicate with the other road users before making choices as to their own behaviour. For example, they may attempt to seek and temporarily hold the eye gaze of the other to gain acknowledgement that the other is aware of their presence. They may wave their hand to indicate that they are giving way to the other. Alternatively, they may hold their hand and arm out to "command" the other to slow or stop as they make their movement. Communication may also take place as the pedestrian or cyclist completes their action, such as a smile, nod or wave to thank the other for yielding or more hostile hand gestures and swearing out loud to indicate displeasure with the other's behaviour. As AVs do not have a human operator (although they are likely at present to have a safety steward on-board), will this impact interactions? While there is anecdotal evidence for such communication in road user interactions, there appears to be both a lack of empirical study and a lack of empirical evidence of this. One exploratory USA study (Rothenbücher, Li, Sirkin, Mok & Ju, 2016), where an apparent AV (the human driver and sole occupant of the car was hidden from view using a "Wizard of Oz" method) interacted with pedestrians and cyclists at a crossing point on campus, noted that while participants looked in the direction of the vehicle, only two out of the 67 observed made an explicit communication attempt. These two participants were also the only two not to cross in front of the vehicle but rather cross behind it. Indeed, participants' crossing behaviours were described overall as "normal" and "not shy". A subset of the observed participants were interviewed after the crossing interaction and the majority

(87%) confirmed that they thought the vehicle was driverless. Thus, it could be hypothesised that explicit communication attempts will be rare in direct interactions with actual AVs.

1.4 Focus of Current Research

The focus of the research about to be described in this report is on perceptions of, and behaviours around, AVs (i.e. small, road-based passenger AVs). Perceptions were investigated via online surveys. In order to make comparisons with existing survey research findings and extend understanding further, the surveys aimed to capture not only passenger but also pedestrian perceptions. Also captured were perceptions of AVs both when more hypothetical and when more tangible phenomena, with one survey being administered before ("Pre-Trial") and one during ("Trial 1") a research trial where AVs operated in a public setting. This trial afforded the opportunity to supplement original data on people's thoughts and feelings about AVs with original data on their actions around them. Behaviours were examined via an observational study. In this study, coders watched and manually recorded members of the public during crossing and passing interactions with the AVs. The main focus was on pedestrian behaviours but those of other road users (e.g. cyclists) were observed in addition. As the trial site was a shared space, baseline road user behaviours in the shared lane were observed also. Altogether, the research was designed to provide insight into the potential for AVs and other road users to safely intermix in a shared environment.

2 Methods

2.1 Pre-Trial Survey

2.1.1 Participants

An online questionnaire survey examining self-reported perceptions of AVs was advertised to members of the UK public via websites, social media, and academic electronic notification systems. The participant information mentioned that pedestrian as well as passenger perspectives would be investigated. It also mentioned that participation was voluntary and anonymous; no incentives were offered for taking part.

Surveys were received during a period of approximately six months, from Spring through to Autumn, in 2016. A total of 1048 surveys were completed. Those that were from participants who were either not resident in the UK, who indicated that they were under 18 years of age, or who indicated that they had completed the survey before, were excluded. Weighting of the remaining data, to be representative of the UK population gender profile, reduced the overall sample size further, to 916 participants. The characteristics of the final pre-trial sample are displayed in Table 1.

Table 1. Characteristics of the pre-trial survey sample (N = 916)

Gender		Age			Driver Status	
Male	Female	M (SD)	Mdn	Range	Driver	Non-Driver
49%	51%	40.91 years (12.93)	39 years	18-85 years	85%	15%

2.1.2 Materials

The online pre-trial survey consisted of two sections: “Background”, with questions on socio-demographic variables and risk-taking, and “Perception of Vehicles”, which – amongst other things – asked about perceived risk and general attitude. On average, the survey took under 10 minutes to complete.

Risk-Taking. A short six-item instrument was designed and presented to capture participants’ propensities for taking road user risks. Its brevity was necessary in order to keep the survey to a reasonable length overall. Its focus was purely on risky behaviours in a road user (i.e. road safety) context because previous research has shown that risk-taking is domain specific (Blais & Weber, 2006). That is, someone who frequently takes, say, financial risks (e.g. gambles), will not necessary be likely to take ethical risks (e.g. cheat on an exam). Similarly, someone who frequently partakes in financial or ethical risks will not necessarily engage in risky behaviour related to their health and safety. Thus, it was important that the risk-taking instrument used here related to the specific domain of interest. Three items were taken from the DOSPERT Risk-Taking Scale (Blais & Weber, 2006), all from its Health/Safety subscale and all related to road user behaviours: “Driving a car without wearing a seatbelt”, “Walking home alone at night in an unsafe area of town”, and “Riding a bicycle without wearing a helmet” (note, the latter item was modified slightly, with the original “motorcycle” changed to “bicycle”). Three further items were newly created and added: “Getting in a car with a driver who you know to have had two alcoholic drinks at a bar”, “Exceeding the speed limit on a motorway (freeway)” and “Crossing the road when the ‘don’t walk’ sign is indicated”). Participants were asked to rate their likelihood of engaging in each of the six listed behaviours using a seven-point scale (where 1 = “Extremely Unlikely”, 2 = “Moderately Unlikely”, 3 = “Somewhat Unlikely”, 4 = “Not Sure”, 5 = “Somewhat Likely”, 6 = “Moderately Likely”, and 7 = “Extremely Likely”). This rating scale, and user instructions, were also taken from the DOSPERT Risk-Taking Scale. The ratings were then added together to give an overall summed score. The higher the summed score, the greater the propensity to take road user risks.

Perceived Risk. In order to gauge how safe (or not) participants perceived AVs to be, the survey asked them to rate the level of risk they thought AVs posed. Risk was defined to participants as “the potential for an accident to occur, resulting in unwanted negative consequences to one’s own life or health”. However, small road-based passenger AVs were still a hypothetical concept for the pre-trial sample. Therefore, for contextual purposes, participants were asked to provide perceived risk ratings not just for such an AV but also for other modes of transport, including their human-operated equivalent (i.e. the conventional passenger car) and existing, larger, track-based passenger AVs (i.e. a driverless train such as the DLR). The pre-trial sample were also asked to provide perceived risk ratings from the perspective of different road user groups. That is, from the perspective of (a) the driver/rider of a human-operated car, motorcycle, and bicycle; (b) a passenger of a train and car, both human-operated and driverless; and (c) a pedestrian travelling in the vicinity of cars, both human-operated and driverless. Of key interest were the passenger- and pedestrian-perspective ratings for AV cars. Perceived risk ratings were made using a seven-point scale (where 1 = “Extremely Low”, 2 = “Moderately Low”, 3 = “Somewhat Low”, 4 = “Not Sure”, 5 = “Somewhat High”, 6 = “Moderately High”, and 7 = “Extremely High”). The higher the rating, the greater the perceived risk.

General Attitude. At the end of the survey, the following question was posed: "Within the next 20 years, driverless vehicles may become the norm on our public roads. Which statement best sums up your attitude to the future use of driverless vehicles on public roads?" Participants could select from one of the statements provided that represented the following five attitudes respectively: "positive" (they explicitly accepted the prospect of AVs); "conditionally positive" (they accepted the prospect of AVs, although with a caveat, i.e. only if certain conditions existed); "uncertain" (they neither explicitly accepted nor opposed the prospect of AVs but more typically had some concerns or questions); "conditionally negative" (they opposed the prospect of AVs, although with a caveat); and "negative" (they explicitly opposed the prospect of AVs). Instead of selecting one of the statements provided, pre-trial participants could also choose to sum up their general attitude using their own words. Each of these freely-worded statements was subsequently coded into one of the five attitude categories.

2.2 Trial 1 Survey

2.2.1 Trial 1 Procedure

Trial 1 took place at the Greenwich Peninsula over a period of approximately one month during Winter, in 2018. For this research trial, a small fleet of electric driverless shuttle pods (see Fig. 1; maximum speed 15 km/h or 4.17 m/s or approximately 10 mph) ran along the Thames Path, in both directions, between the InterContinental Hotel and John Harrison Way (see Fig. 2). Operating times were Mondays to Fridays, during daytime hours. Each pod carried a safety steward and had room for up to three passengers, with seating arranged so all occupants faced inwards.

Fig.1. A driverless shuttle pod used in Trial 1

Fig.2. Trial 1 pod route

As the Thames Path is for public use, pods could and did encounter other road users on foot (walking, jogging) and on bicycles during their runs. Except for by the North Greenwich Pier, which is a single lane area, most of the pod route was dual lane, with markings painted on the ground to indicate that pedestrians and cyclists should use one lane while the pods would operate in the other (see Fig. 3). However, this was not mandatory, nor necessarily observed by the public. Moreover, there were occasions when pods would have to move into the other lane (e.g. when passing another pod). Thus, there were several ways and scenarios in which members of the public could interact with the pods.

Fig. 3. Dual-lane markings painted on ground on Trial 1 pod route

2.2.2 Participants

Members of the public who had interacted with a pod, either as a passenger, pedestrian or cyclist, were invited to complete an online questionnaire survey examining self-reported perceptions of and interactions with the AVs. As several GATEway partners would be surveying the public during Trial 1, and to therefore avoid survey competition and fatigue, recruitment for the survey described here was conducted in limited stages: first, passengers during Week 1 of the trial (n = 114 participants) received an email invitation; second, all staff and students at the University of Greenwich (plus their family and friends) were invited via email and academic electronic notification systems; then, thirdly, at the end of the trial, several local businesses and local walking/jogging/cycling groups were asked to share the survey link with their staff and members via email and social media. As with the pre-trial survey, the participant information mentioned that participation was voluntary and anonymous; no incentives were offered for taking part.

The following analysis is based only on surveys received during the four-week period prior to this report being prepared; thus, it should be noted that the results may be subject to change. A total of 66 surveys were completed. One was excluded due to the responses indicating a lack of due care or attention. Thus the final Trial 1 survey sample size was 65 participants. Their characteristics are displayed in Table 2. As can be seen in that table, the majority of Trial 1 survey participants were describing passenger interactions with the pods.

Table 2. Characteristics of the Trial 1 survey sample, overall and by road user group

	Gender		Age			Driver Status	
	Male	Female	M (SD)	Mdn (IQR)	Range	Driver	Non-Driver
Overall (N =65)	55%	45%	36.72 years (13.65)	35 years (24.5-46.0)	18-72 years	63%	37%
Passengers (n = 57)	54%	46%	35.61 years (12.31)	34 years (24.5-45.0)	18-63 years	63%	37%
Pedestrians (n = 7)	57%	43%	40.71 years (18.32)	39 years (23.0-61.0)	20-67 years	71%	29%
Cyclists (n = 1)	100%	--	--	72 years --	--	--	100%

2.2.3 Materials

The online Trial 1 survey consisted of five sections: "Interaction Experience", with questions on the interaction, including perceived risk; "Transport and Risk Behaviour", on transport usage habits and risk-taking; "Individual Characteristics", collecting socio-demographic information; "Acceptance", on changed perceptions and general attitude; "And Finally…", a check on whether participants had completed any other GATEway surveys previously (only three had). Despite having more sections than the pre-trial survey, there were deliberately fewer questions within some, given the aforementioned desire to avoid survey fatigue. Thus, this survey took approximately 5 minutes to complete.

Risk-Taking. The same short six-item instrument as that described in Section 2.1.2 was used to capture Trial 1 participants' propensities for taking road user risks.

Perceived Risk. The same rating scale and instructions as that described in Section 2.1.2 were used to gauge how safe (or not) participants perceived the pod to be. However, Trial 1 participants were not asked to make similar risk ratings for other modes of transport or from any other road user perspective than the one relevant to their pod interaction.

General Attitude. The same instructions and five attitude categories as that described in Section 2.1.2 were used to establish Trial 1 participants' general attitudes towards the prospect of AVs being on the public roads in the future. This time, participants were not given the choice to sum up their attitude using their own words. However, they could provide statements to elaborate on caveats if they selected "conditionally positive" or "conditionally negative".

Transport Usage Habits. To ascertain what mode(s) of transport participants used most frequently when travelling, a list was provided, including private motorised transport (car, as a driver and as a passenger, and motorcycle), public motorised transport (train, bus), and non-motorised modes of transport (walking, cycling). Participants were asked to rate their usage frequency using a four-point scale (where 1 = “Most Days”, 2 = “Some Days”, 3 = “Rarely”, and 4 = “Never”). The mode(s) that received the highest rating relative to all other modes was coded as the one used most frequently.

Changed Perceptions. To examine what impact the pod interaction had on participants’ perceptions of AVs in general, the Trial 1 sample was asked directly. Participants could choose from one of five answer options: “My perception of driverless vehicles was positive and this has not changed”, “I now have a more positive perception of driverless vehicles than I did before”, “Not sure”, “I now have a less positive perception of driverless vehicles than I did before”, “My perception of driverless vehicles was negative and this has not changed”.

2.3 Trial 1 Observational Study

2.3.1 Observational Study Procedure

The observational study was conducted on the Thames Path during times of peak footfall (i.e. typically between 12:00 and 14:00 each day, weather permitting). Two coders, dressed inconspicuously, located themselves in areas outside of the pod or pedestrian/cyclist/shared lanes, where they had a good vantage point. The coders independently recorded, using a paper checklist, behaviours observed. The observed behaviours were from one of two scenarios of interest:

i. Crossing interactions between road users and pods by the junction near the Emirates Air Line cable car terminal
ii. Passing interactions between road users and pods in the single, shared lane near the North Greenwich Pier ferry terminal (see Fig. 2)

However, for the shared lane, it was also necessary to observe baseline road user behaviours when pods were not present. This would help put passing interaction behaviour into context. Thus, additional observations took place, again during weekdays, typically between 12:00 and 14:00.

As well as recording behaviours, the coders noted the following setting details during each data collection period:

- Their observational location
- When data collection took place – i.e. week of trial, day of week, time of day
- Environmental conditions – i.e. light period (always daylight), temperature in degrees Celsius (as reported on the Met Office website for "The O2"), wind speed in miles per hour (ibid), visibility (ibid), weather conditions (with advice provided to coders on how to classify "sunny", "fine", "rain", "snow", "hail", "cloudy", "overcast", "windy", "fog/mist"), and road surface conditions (again, with advice on classifying "dry", "moist", "wet", "snowy", "icy", "slushy", "treated")

If light rain fell during the observational study, the coders continued to observe. However, if heavier rain fell, data collection was postponed as earlier site feasibility visits had demonstrated that footfall reduced noticeably during precipitation. The environmental and road surface conditions during the Trial 1 and baseline sample observations were similar (i.e. always cloudy to overcast; median temperature of 9 degrees Celsius for both; median wind speed of 11 mph for both; visibility most frequently "good" for both, otherwise "very good"; road surface condition most frequently "dry" for both, otherwise "moist").

2.3.2 Participants

As the Thames Path is a public space where members of the public have no reasonable expectation of privacy, consent was not sought from observed road users to be included in the study. At no point did a member of the public approach or otherwise indicate to a coder that they were unwilling to have themself, or anyone else, be subject to observation. Indeed, many road users would have been unaware that their behaviour was being noted as the coders attempted to keep their activity discreet, where possible recording their observations after the road users had passed by.

The road users of interest were pedestrians (defined for coding purposes as persons on foot travelling at walking speed), joggers (persons on foot travelling at running speed, with both feet leaving the ground at times), and cyclists (travelling on bicycles; persons seen pushing bicycles as they walked along were classified as pedestrians). These road users could be of any gender, and of any age; however, no observations were made of children travelling on their own. In situations involving groups of road users that included children, only the adult behaviour was coded. Adults were classified into one of three categories: "young adult" (approximately 18 to 29 years old), "adult" (approximately 30 to 64 years old), or "older adult" (approximately 65+ years old). Group size was also classified into one of three categories: "alone" (person unaccompanied), "2" (person was travelling in a pair), or "3+" (person was travelling with two or more other persons). Coders drew upon the observed person's behaviour towards others to help with classification (e.g. if holding hands, engaged in conversation, or transporting them in a buggy, then they were considered to be in a group; if there was no overt interaction with the others but they were travelling in very close proximity, and mirroring their movements, then they were also considered to be in a group). The characteristics of the Trial 1 and baseline samples are displayed in Table 3.

Table 3. Characteristics of the Trial 1 and baseline observational study samples

	Road User			Gender		Age			Group Size		
	Ped.	Jog.	Cyc.	M	F	YA	A	OA	Alone	2	3+
Trial 1 Overall (N = 330)	85%	8%	7%	69%	31%	20%	72%	8%	63%	21%	16%
Crossing (n = 66)	97%	3%	0%	68%	32%	21%	73%	6%	73%	20%	8%
Passing (n = 264)	83%	9%	9%	69%	31%	20%	72%	8%	61%	21%	18%
Baseline (N = 238)	83%	10%	7%	56%	44%	23%	68%	9%	39%	43%	18%

Note: Ped = Pedestrian, Jog. = Jogger, Cyc. = Cyclist, M = Male, F = Female, YA = Young Adult, A = Adult, OA = Older Adult

Road users walking a dog (6 cases in total) were included in the observational study, as were road users wheeling items (26 cases in total, most often a buggy, but also occasionally suitcases or bicycles). Only one road user was observed using a mobility aid and they were also included in the study.

2.3.3 Materials

Behaviours observed during crossing and passing interactions were recorded in shorthand form on the checklist alongside the aforementioned setting and participant details. For crossings, the behaviours of interest were as follows:

- Crossing Choice – when a pod approached, the road user either crossed in front of it, behind it, or waited for it to pass first and then crossed
- Distance Gap – the approaching pod was either fewer or more than 10 metres away from the road user when they made their crossing choice (to know if a pod was within or beyond the 10-metres point, the coders had earlier measured the distance from the crossing to various physical landmarks in its vicinity (e.g. yellow markings painted on ground, street sign, sign posts) and noted the pod's position relative to those)
- Inattention – the road user was either not paying attention to the approaching pod (e.g. preoccupied with mobile phone, conversation) or paid it due attention (i.e. directed visual attention towards the pod)
- Hesitation – the road user visibly hesitated during the early stages of the interaction with the pod (i.e. started to move forward then stopped or even retreated) or displayed no hesitation (i.e. confidently stepped out and continued crossing in this manner)
- Lanes Crossed – the road user crossed either just the pod's lane, which was 3.3 metres wide (i.e. stepped off the pavement by the junction and stopped crossing once within the pedestrian/cyclist lane or, from the pedestrian/cyclist lane, crossed over to the pavement by the junction) or the road user crossed both the pod lane and the pedestrian/cyclist lane, a distance of 6.7 metres (i.e. stepped off of the pavement on one side and stopped crossing once onto the pavement at the other side; see Fig. 4)
- Change of Speed – the road user either displayed no change of speed as they crossed in the vicinity of the pod, or accelerated (e.g. started off ambling but then walked fast/ran the rest of the way), or decelerated (e.g. started off walking fast but then slowed and ambled the rest of the way)
- Communication Attempt – the road user tried to communicate with the pod and/or its occupants during the crossing interaction (i.e. directed a verbal comment or hand gesture – friendly or hostile – towards the pod, or moved up close to the pod and peered inside, as if trying to make eye contact with occupants)

Note, the crossing point was a non-designated crossing place, so there were no markings or traffic signals to dictate behaviours during crossing interactions. Also, to be considered for observation, participants had to be arriving at the crossing point when a pod was within a pre-determined "interaction zone" (i.e. approximately 20 metres either side of the crossing point); if participants were already on the crossing before the pod reached the zone, they were not coded.

Fig. 4. Crossing point by junction, with pedestrian/cyclist lane (left) and pod lane (right)

For passing interactions, the behaviours of interest were:

- Direction of Travel – the road user was either travelling along the shared lane in the direction of the InterContinental Hotel or travelling in the opposite direction towards John Harrison Way
- Approach – either the road user approached the pod from head-on, or from behind, or the pod approached the road user from behind
- Orientation – during the attempt to pass or be passed by the pod, the road user either kept or moved to the left of the shared lane, remained in place in the middle of/spread across the lane, or kept or moved to the right of the lane
- Change of Speed – the road user either displayed no change of speed during the passing interaction, or accelerated (e.g. started off ambling but then walked fast/ran until clear of the pod), or decelerated (e.g. started off walking but then slowed to a stop until the pod had passed)

- Communication Attempt – the road user tried to communicate with the pod and/or its occupants during the passing interaction (i.e. in the same way as in crossing interactions)

Note, while markings had been painted on the ground to notify road users that pods would be operating in the single lane, there was also signage located nearby explaining that the area ahead was a shared space (see Fig. 5). Thus, no type of road user had a designated right of way over others in the lane. Also, to be considered for observation, participants had to be in the pre-determined "interaction zone" (approximately 30 metres long and 3.5 metres wide) at the same time as a pod; if they were outside of that zone, or outside of the shared lane (e.g. just inside the ferry boarding area at the pier), they were not coded.

Fig.5. Shared lane with pod markings on ground (left) and signage nearby (right)

Baseline behaviours of interest in the shared lane were similar to some of those during the passing interactions; that is, in addition to the setting and participant details, coders noted the following:

- Direction of Travel – the road user was either travelling along the shared lane in the direction of the InterContinental Hotel or travelling in the opposite direction towards John Harrison Way
- Orientation – as they travelled, the road user either kept to the left of the shared lane, moved in the middle of or spread across the lane, or travelled on the right of the lane

2.3.4 Coder Reliability

The coders used in the observational study both had experience in analysing people's behaviour through either direct observation or through viewing video footage. In addition, the coders undertook gender and age estimation training and testing prior to Trial 1. With the copyright holder's permission, photographic stimuli were extracted from the 10k US Adult Faces Database (Bainbridge, Isola & Oliva, 2013), with equal numbers for each gender and age category (ranging from young to older adults). The stimuli were presented in random order to coders, whose task was to independently classify the individuals shown into the gender and age categories. The correct answers were revealed subsequently. For the test, coders were presented with images of 90 different individuals. Few errors were made on classifying gender; more were made on classifying age. Nevertheless, both coders achieved high overall accuracy scores (greater than 88%).

Still during preparation for Trial 1, the coders made multiple visits to the trial site and informally observed road user baseline behaviours. At moments during some of these visits, pods were present (as their hardware and software were being tested). Although they were often under manual control, this nonetheless afforded an opportunity to observe behaviours of interest for Trial 1 and refine the behaviours checklist and codes for crossing and passing interactions.

Coders undertook further independent practice with the behaviours checklist on the eve of Trial 1 (with pods present and operating in driverless mode) before performing a formal test of inter-coder reliability at the start of Trial 1. The same 25 road users were independently observed and coded; substantial agreement was found between the two coders' observational classifications on age (Cohen's kappa = .78, $p < .001$) and almost perfect agreement was found on all other coded aspects (all kappas > .90, all ps < .001).

2.4 Pre-Trial and Trial 1 Data Analysis

2.4.1 Data Analysis

IBM SPSS Statistics version 22 was the software package used for all data analyses. Its Complex Samples module (more specifically, its CSGLM and

CSLOGISTIC procedures) was additionally used for analysing the pre-trial survey weighted data. The alpha (statistical significance) level for analyses was $p < .05$. Where post hoc tests involving multiple comparisons were performed, a Bonferroni correction was applied.

The psychometric properties of the risk-taking instrument were assessed using a principal factor analysis with the direct oblimin oblique rotation method on the pre-trial data. From this analysis, and inspection of a scree plot, it emerged that just one factor – i.e. a single risk-taking dimension – was underlying the instrument (eigenvalue > 1, explaining approximately 36% of the variance). However, the item about driving without a seatbelt did not load highly on this factor. Moreover, when assessing the reliability of the instrument, the removal of this item improved the Cronbach's alpha value, both for the pre-trial (Cronbach's alpha = 0.65) and Trial 1 (Cronbach's alpha = 0.69) data. Thus, the risk-taking summed scores used in the analyses reported in Section 3 were calculated using just responses to the remaining five items.

The direction of travel was missing from some passing interaction observations. These missing cases were excluded from the analysis where such detail was relevant and the n's adjusted (see Tables 11 and 13).

2.4.2 Further Information

Further details of the methods employed and analyses performed on the pre-trial data can be found in a journal article by Hulse, Xie and Galea (2018).

3 Results

3.1 Survey Data

3.1.1 Perceived Risk

Overall, the perceived risk ratings for an AV given by the pre-trial sample approximated 3 (Passenger: $M = 3.18$, $SD = 1.61$; Pedestrian: $M = 3.20$, $SD = 1.61$); that is, they imagined AVs to pose a "somewhat low risk" towards them.

This was similar to the perceived risk ratings given for a human-operated car (Driver: M = 2.98, SD = 1.54; Passenger: M = 2.90, SD = 1.43; Pedestrian: M = 3.52, SD = 1.57). Trains – human-operated as well as driverless – were perceived to pose an even lower level of risk (Train Passenger: M = 1.71, SD = 1.10; AV Train Passenger: M = 1.72, SD = 1.10) while, in contrast, two-wheeled modes of transport were perceived as high risk (Motorcycle Rider: M = 4.97, SD = 1.56; Bicycle Rider: M = 5.20, SD = 1.54).

Extremely	Moderately LOW	Somewhat	Not Sure	Somewhat	Moderately HIGH	Extremely
1	2	3	4	5	6	7
Trial 1: AV	Pre-Trial: Train, AV Train	Pre-Trial: Car, AV		Pre-Trial: Motorcycle, Bicycle		

Fig.6. Perceived risk posed by AVs and other modes of transport

The Trial 1 sample had actual experience of interacting with a small road-based passenger AV. Overall, their AV risk rating was more favourable (see Fig. 6), approximating 1 (Mdn = 1, IQR = 1-2; M = 1.77, SD = 1.09); in other words, AVs were perceived as only posing an “extremely low risk” towards these participants.

3.1.2 Perceived Risk – Relationships with Other Factors

In the pre-trial sample, participants imagined that travelling as a passenger in an AV would pose significantly greater risk to them than travelling as a passenger in a human-operated car ($t(915) = 4.26$, $p < .001$). In contrast, they imagined that travelling as a pedestrian in the vicinity of AVs would pose significantly less risk to them than travelling as a pedestrian in the vicinity of human-operated cars ($t(915) = -4.53$, $p < .001$).

Further differences were evident in the pre-trial sample. Whether responding from the perspective of a passenger or of a pedestrian, females gave significantly higher perceived risk ratings for AVs than did males (Female

Passenger: M = 3.54, SD = 1.63; Male Passenger: M = 2.79, SD = 1.49; F(1, 915) = 49.81, p < .001; Female Pedestrian: M = 3.61, SD = 1.63; Male Pedestrian: M = 2.77, SD = 1.47; F(1, 915) = 58.69, p < .001).

When examining the pre-trial sample's perceived risk for travelling in and around human-operated cars, significant associations were detected between risk ratings and both age and the propensity for taking road-user risks. This was not the case when examining their perceived risk for travelling in and around AVs (Passenger – Age: r = .01; F(1, 915) = 0.97, p = .326; Pedestrian – Age: r = -.02; F(1, 915) = 0.00, p = .951; Passenger – Risk-Taking: r = -.01; F(1, 915) = 1.54, p = .215; Pedestrian – Risk-Taking: r = -.04; F(1, 915) = 0.22, p = .638).

Extremely	Moderately LOW	Somewhat	Not Sure	Somewhat	Moderately HIGH	Extremely
1	2	3	4	5	6	7
Trial 1: Passenger; Female	Trial 1: Pedestrian, Cyclist; Male					

Fig.7. Perceived risk posed by the Trial 1 AVs, by road user and gender

In the Trial 1 sample, the number of completed surveys from pedestrians (and cyclists) to date compared to passengers is low, precluding any inferential statistical analysis by road user group. However, descriptive statistics are included here to give an indication of the pattern of responding thus far. Passengers' risk ratings approximated 1 (Mdn = 1, IQR = 1-2; M = 1.65, SD = 0.88), indicating that this group of participants perceived the AVs to pose only an "extremely low risk" to them. Pedestrians' risk ratings approximated 2 (Mdn = 2, IQR = 1-5; M = 2.71, SD = 2.06), indicating that this group perceived the AVs as posing a slightly greater risk to them, in comparison, but still a low risk nonetheless (i.e. "moderately low risk"). The sole cyclist participant gave a perceived risk rating of 2 and thus also viewed the AVs as posing "moderately low risk" (see Fig. 7).

Unlike in the pre-trial sample, no gender differences in perceived risk were detected in Trial 1. In other words, overall, females tended to give lower perceived risk ratings for AVs than did males, but not significantly lower (Female Overall: Mdn = 1, IQR = 1-2, M = 1.55, SD = 0.91; Male Overall: Mdn = 2, IQR = 1-

2, M = 1.94, SD = 1.19; U = 411.50, p = .108). This remained the case when only the passenger participants' ratings were analysed by gender (Female Passenger: Mdn = 1, IQR = 1-2, M = 1.58, SD = 0.95; Male Passenger: Mdn = 2, IQR = 1-2, M = 1.71, SD = 0.82; U = 347.00, p = .317).

Consistent with the pre-trial sample, age and perceived risk ratings were not significantly associated with one another, either when looking at the Trial 1 sample overall (r_s = -.05, p = .713) or just the passenger group (r_s = -.16, p = .239). Likewise, there were no significant associations between the propensity for risk taking and perceived risk ratings, for the overall sample (r_s = .20, p = .111) or for the passenger group (r_s = .12, p = .362).

3.1.3 General Attitude

When asked about their attitude towards AVs being on the public roads in the future, the pre-trial sample were most often "uncertain" about this prospect (46% of participants). A slightly lower combined percentage (43%) had a "positive" or "conditionally positive" attitude. Only a tenth of the pre-trial sample (10% combined) had a "conditionally negative" or "negative" attitude.

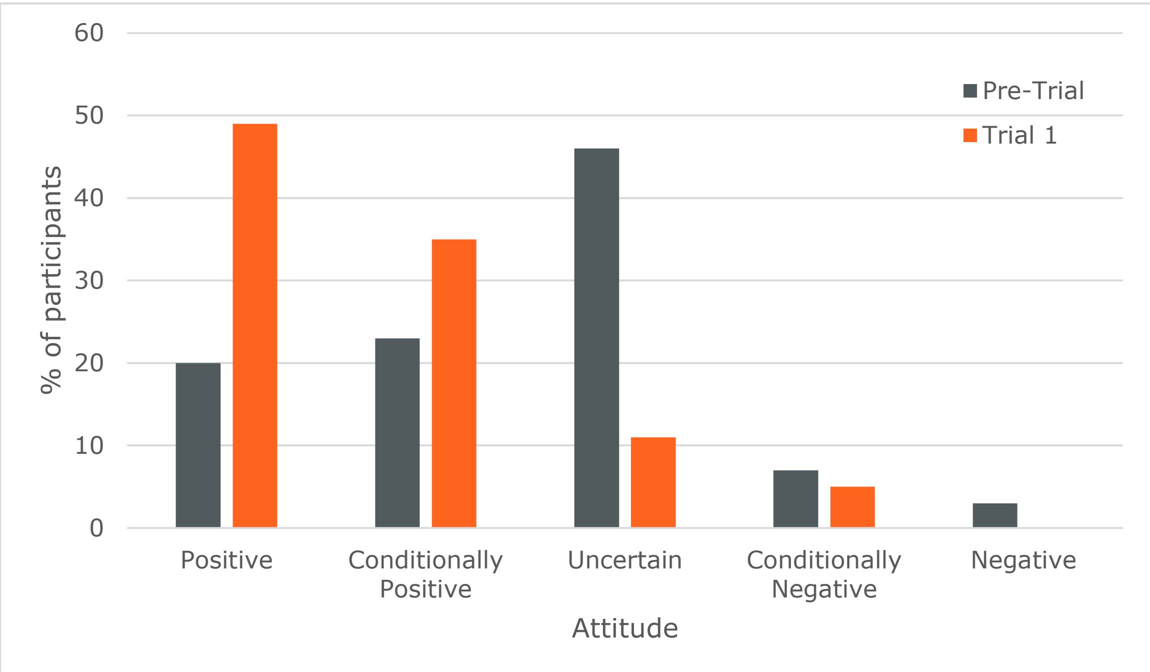

Fig.8. Attitudes towards AVs on public roads in the future

In comparison, the Trial 1 sample appeared much more in favour of the prospect of AVs on public roads (see Fig. 8): the vast majority (84% combined) had a “positive” or “conditionally positive” attitude. Only around a tenth (11%) were “uncertain”, while few had a “conditionally negative” or “negative” attitude (5% and zero, respectively).

3.1.4 General Attitude – Relationships with Other Factors

As the pre-trial sample was large, it was possible to test for predictors of general attitudes using a form of logistic regression. Attitudes was the dependent variable (with “uncertain” selected as the reference category), and gender, age, risk-taking, and perceived risk (from the perspective of both a passenger and a pedestrian) were all entered in the model as independent variables. In addition, driver status was included as a further independent variable, given that attitudes towards AVs could be influenced by factors not only related to risk/safety but also, for example, a passion for driving.

In summary, the regression test (Model $\chi^2(24) = 143.88$, $p < .001$; Nagelkerke $R^2 = .28$) showed that the following independent variables were significant predictors of attitudes:

- Gender – males were more likely to have a positive attitude than females ($b = 0.61$, $SE = 0.22$, $p = .006$, odds ratio = 1.84)
- Age – younger adults were more likely to have a positive attitude ($b = -0.02$, $SE = 0.01$, $p = .039$, odds ratio = 0.98), while older adults were more likely to have a negative attitude ($b = 0.06$, $SE = 0.02$, $p < .001$, odds ratio = 1.06)
- Perceived risk, from the perspective of a passenger – from this viewpoint, participants who perceived AVs as posing lower risk were more likely to have a positive ($b = -0.39$, $SE = 0.11$, $p < .001$, odds ratio = 0.67) or a conditionally positive ($b = -0.24$, $SE = 0.09$, $p = .008$, odds ratio = 0.79) attitude
- Perceived risk, from the perspective of a pedestrian – from this other road user viewpoint, participants who perceived AVs as posing lower risk were also more likely to have a positive attitude ($b = -0.48$, $SE = 0.12$, $p < .001$, odds ratio = 0.62), while those who perceived AVs as posing greater risk were more likely to have a negative attitude ($b = 0.74$, $SE = 0.21$, $p < .001$, odds ratio = 2.09)

Neither risk-taking nor driver status (all ps > .244, all odds ratios < 1.20) were found to be significant predictors of attitudes towards the prospect of AVs on public roads.

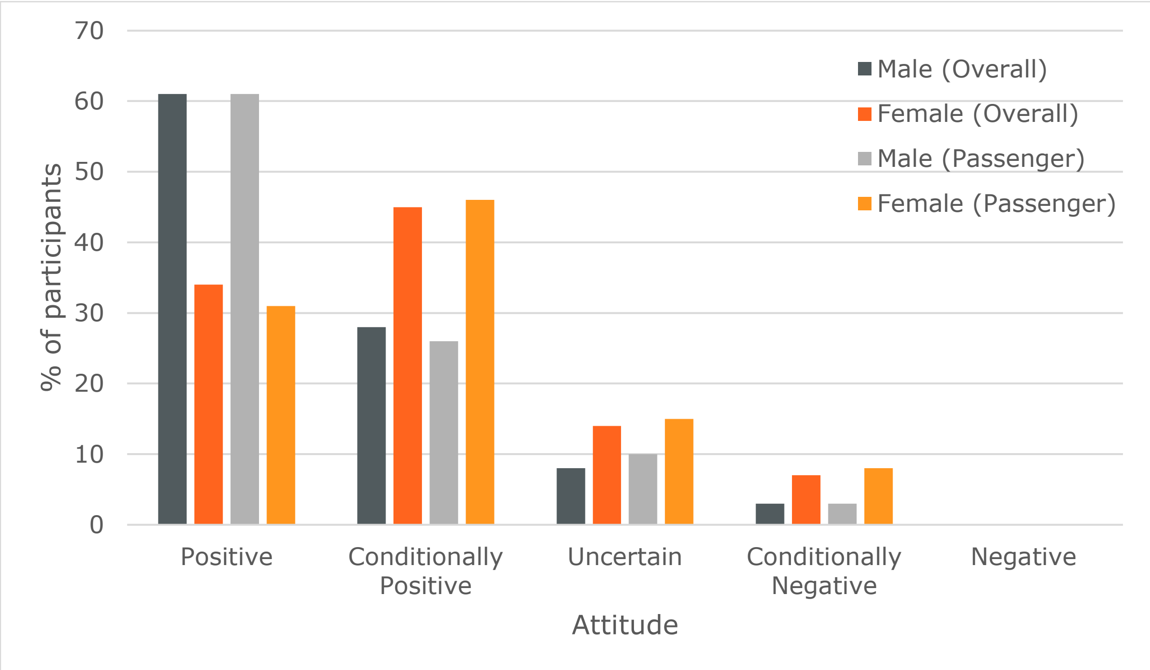

Fig.9. Trial 1 attitudes, by gender, towards AVs on public roads in the future

With a smaller sample size, Trial 1 attitudes were examined by gender, age, risk-taking, perceived risk and driver status on an individual basis, using different inferential statistical tests. Again, due to the low number of completed surveys from pedestrians/cyclists to date, no inferential comparison of attitudes by road user group was conducted, although it may be of interest to note that the responses from the pedestrian group (57% "positive", 43% "conditionally positive") and sole cyclist ("positive") all appeared favourable towards the prospect of AVs.

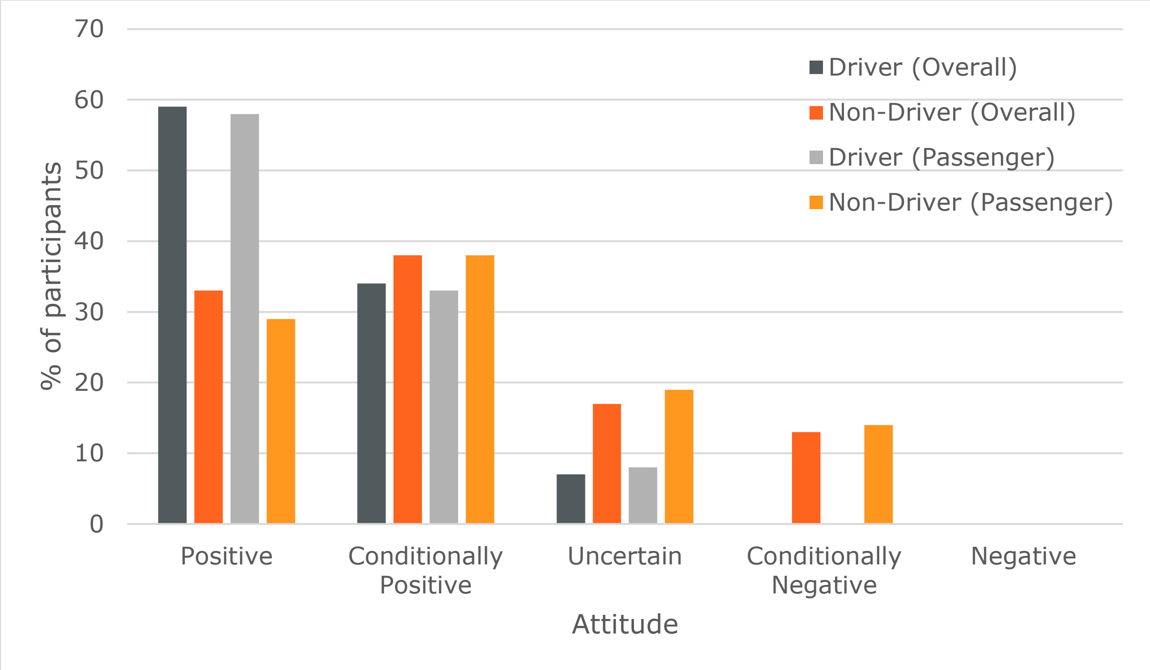

Fig.10. Trial 1 attitudes, by driver status, towards AVs on public roads in future

Significant gender differences were detected, with males displaying more positive attitudes than females (see Fig. 9); this was the case when examining the Trial 1 sample overall (U = 378.00, p = .038) and when looking at just the passenger group (U = 279.00, p = .031). Furthermore, and contrary to the pre-trial results, significant differences in attitudes were found (both overall and for the passenger group, see Fig. 10) according to driver status; i.e. drivers displayed more positive attitudes and fewer conditionally negative attitudes than did non-drivers (Overall: U = 328.00, p = .015; Passenger: U = 231.00, p = .008). Also contrary to the pre-trial results, there was no significant association between attitudes and age in Trial 1 (Overall: r_s = -.05, p = .678; Passenger: r_s = -.08, p = .544), nor between attitudes and perceived risk (Overall: r_s = .16, p = .216; Passenger: r_s = .17, p = .202). However, the lack of a significant association between attitudes and risk-taking in Trial 1 was consistent with the result from the earlier sample (Overall: r_s = .18, p = .152; Passenger: r_s = .16, p = .229).

3.1.5 General Attitude – Stated Caveats

In both the pre-trial and Trial 1 surveys, participants could provide statements to better demonstrate their general attitude, i.e. outline the caveats that resulted in their attitudes being “conditionally positive” or “conditionally negative" rather than "positive" or "negative". While the statements from both samples covered diverse issues such as the hacking of software, programmed behavioural rules, a passion for driving, liability, and so forth, it was clear that each sample had a particular concern. For the pre-trial sample, the caveats categorised under "conditionally positive" typically centred on safety testing; there were more than three times as many statements on this issue than on the next most frequently cited issue. In order for those participants to fully accept the prospect of AVs on the public roads, they communicated a need for safety testing to be thorough, regulated and/or demonstrated (see Table 4).

Table 4. Examples of caveats stated for "conditionally positive" attitudes

Pre-Trial Examples	Trial 1 Examples
- "I welcome the advancements in technology, provided it has been independently and rigorously (scientifically!) tested/researched."	- "I think that driverless vehicles are inevitable, my concern is with regard to shared space and ensuring safety for all road users."
- "I am really looking forward to them and would like one myself, as I am happy not to have the responsibility of driving. Although I think they need to be properly trialled and tested."	- "This must not happen at the expense of walking and cycling as an active street life is vital to our cities."
- "Compared to human-controlled cars, my concerns about autonomous cars are very, very much lower. Almost all injuries and fatalities are caused by driver error. I would not 'always be concerned' about the safety of autonomous vehicles, in that I wouldn't worry about them all the time. But like any safety-critical equipment/ machinery, I would expect proper regulation, monitoring and for those responsible for unacceptable failures to be held accountable."	- "Driverless cars still experience much difficulty with predicting the behaviour of cyclists and pedestrians. This means that driverless cars cannot really be driverless yet, e.g. the pod that I saw was accompanied by three "guides" and obstructed cyclists by taking up the whole cycling lane. Laws should be introduced that mandate manual driving in areas where pedestrians, cyclists, and other vulnerable road users are dominant."
- "The vehicles are at the cutting edge of technology and are being tested thoroughly. I think there needs to be a practical demonstration of safety features to completely satisfy the unknown elements however my attitude is that they are safer than a human driving as they are always concentrating on the task of driving."	- "There needs to be designated routes for these vehicles and plenty of warning signs and sounds and sometimes a separating rail between foot traffic and vehicles with designated crossing areas."

Safety testing was still a concern for some of the Trial 1 sample. However, the main issue for those selecting "conditionally positive" appeared to be the potential impact of AVs sharing space with vulnerable road users such as pedestrians and cyclists. Participants communicated concerns over the AVs' readiness to intermingle with these groups, and concerns over the AVs coming to dominate their shared spaces, leading to a reduction in walking/cycling (see Table 4). It appeared that participants would fully accept AVs but on the condition that AVs bore the brunt of any adaptation or conforming necessary for their safe integration into shared environments.

As fewer participants were "conditionally negative" in both samples, fewer statements of caveats were provided. However, out of those that were, the main focus in the pre-trial sample was the desire for AVs to have a manual override feature, while for the Trial 1 sample, the focus again was on the concern that AVs would come to dominate shared environments at a cost to vulnerable road users such as pedestrians (see Table 5).

Table 5. Examples of caveats stated for "conditionally negative" attitudes

Pre-Trial Example	Trial 1 Example
- "I am opposed to these vehicles being on the road without emergency manual braking (and maybe steering) available to a human until at least 80% of vehicles are autonomous."	- "If it is at a cost to the public realm e.g. friendly streets/pedestrian oriented."

To see whether this focus on vulnerable road users might be the result of a disproportionate number of dedicated pedestrians and cyclists in the Trial 1 sample, participants' transport usage habits were analysed. In fact, the data showed that participants who most frequently travelled by either walking (25%) or cycling (0%), or a combination of the two modes (3%), were slightly in the minority in the Trial 1 sample overall. Instead, it was revealed that participants most commonly used a mixture of transport modes. Typically, this was a mixture of walking and public motorised transport such as a train or bus (35%). When added to those who most frequently travelled by a mixture of walking, cycling and public transport (3%) and those who most frequently travelled by public transport exclusively (5%), this "mixture/motorised only (excluding car)" group were in the majority in the Trial 1 sample. The "mixture/motorised only (including car)" group – a combination of those most frequently travelling by private motorised transport, i.e. a car (no-one most frequently travelled by motorcycle), either exclusively (9%), or along with walking (11%), or along with walking plus public transport (9%) – were the next largest group. The same pattern of results were seen when examining the transport usage habits of just the passenger group in the Trial 1 sample (see Table 6).

Table 6. Trial 1 sample's most frequently used mode of transport

	Mixture/Motorised Only (inc. car)	Mixture/Motorised Only (exc. car)	Non-Motorised (walking/cycling)
Trial 1 Overall	29%	43%	28%
Trial 1 Passengers	33%	44%	23%

Further analysis showed that there was no significant association between general attitudes and whether participants most frequently travelled by car (either mixed with other modes of transport or exclusively), by public transport (either mixed with other modes of transport excluding a car, or exclusively), or by non-motorised modes of transport, i.e. walking and/or cycling (Overall: $\chi^2(2) = 1.45$, $p = .485$; Passenger: $\chi^2(2) = 2.74$, $p = .254$).

3.1.6 Changed Perceptions

Lastly, the Trial 1 survey offered the opportunity to examine how getting to interact with a driverless pod impacted participants' perceptions of AVs in general. The responses indicated that, overall, almost three-quarters of participants had a positive perception of AVs following their interaction, although the majority (55%) reported that they already had a positive perception and the interaction did not change this. Very few participants overall reported already having and retaining a negative perception of AVs (2%), although over a tenth of the sample (11%) reported that their perceptions became less positive following their interaction and slightly more (15%) were left unsure. The pattern of results was very similar when looking only at the Trial 1 passenger group (see Fig. 11).

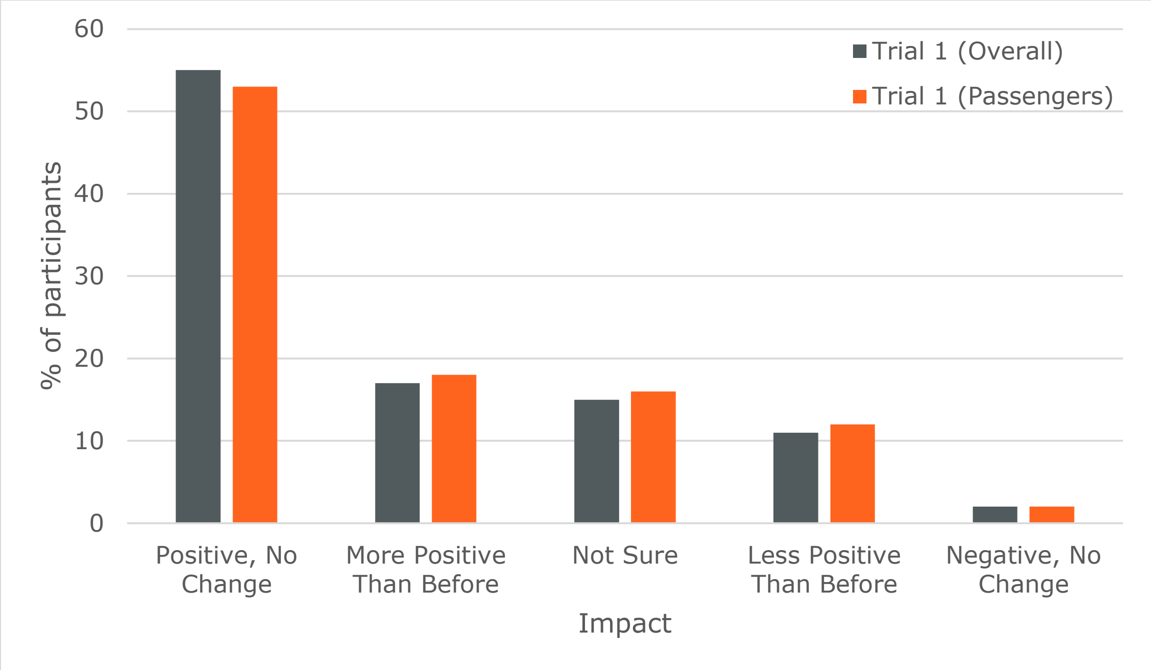

Fig.11. Impact of Trial 1 interaction on perceptions of AVs

Note, those who completed the survey about a pedestrian interaction with a driverless pod also reported having mostly positive perceptions following their interaction (71% "positive, no change", 14% "more positive than before", 14% "not sure"). The sole cyclist interaction also reportedly resulted in the participant retaining their already positive perception.

3.1.7 Changed Perceptions – Relationships with Other Factors

To examine whether the impact on participants' perceptions of AVs was associated with gender, age, risk-taking, driver status or transport usage habits, the survey responses were first re-coded into "changed" ("more positive than before" plus "less positive than before") and "not changed" ("positive, no change" plus "negative, no change"), with "not sure" responses remaining as they were (see Table 7).

No significant associations were detected between impact and gender (Overall: $\chi^2(2) = 0.33$, $p = .850$; Passenger: $\chi^2(2) = 0.02$, $p = .989$). Nor were any significant associations detected between impact and age (Overall: $\chi^2(2) = 0.97$, $p = .615$; Passenger: $\chi^2(2) = 0.52$, $p = .771$), impact and risk-taking (Overall: $\chi^2(2) = 0.48$, $p = .785$; Passenger: $\chi^2(2) = 0.78$, $p = .677$), impact and driver status (Overall: $\chi^2(2)$

= 0.25, p = .883; Passenger: $\chi^2(2) = 0.11$, p = .946), or impact and transport usage habits (Overall: $\chi^2(4) = 4.35$, p = .361; Passenger: $\chi^2(4) = 3.87$, p = .423).

Table 7. Impact of Trial 1 interaction, by gender, age, risk-taking, driver status, transport usage habits

	Trial 1 Overall			Trial 1 Passengers		
	Changed	Not Changed	Not Sure	Changed	Not Changed	Not Sure
By Gender:						
Male	25%	58%	17%	29%	55%	16%
Female	31%	55%	14%	31%	54%	15%
By Age:						
Mdn (IQR)	29.5 (21.8-49.8)	35.0 (26.0-45.0)	44.0 (28.5-49.5)	28 (21.5-50.5)	35 (26.0-44.0)	43 (26.0-48.5)
By Risk-Taking:						
Mdn (IQR)	15.5 (13.0-22.3)	17.0 (13.5-23.0)	16.0 (10.0-20.8)	16.0 (13.5-22.5)	17.0 (13.0-22.0)	14.0 (10.0-21.5)
By Driver Status:						
Driver	27%	56%	17%	31%	53%	17%
Non-Driver	29%	58%	13%	29%	57%	14%
By Transport Usage Habits:						
Mixture/Motorised Only (inc. car)	37%	42%	21%	37%	42%	21%
Mixture/Motorised Only (exc. car)	25%	68%	7%	24%	68%	8%
Non-Motorised (walking/cycling)	22%	56%	22%	31%	46%	23%

3.2 Observational Data

3.2.1 Crossing Interactions

As Table 8 shows, in slightly more than a half of all crossing interactions, participants were observed to cross beyond just the AV lane, traversing both lanes entirely. Despite often travelling this longer distance, almost three quarters of participants overall were observed to accept a gap of fewer than 10 metres during crossing interactions with an approaching pod. However, less than a fifth displayed another risky behaviour: inattention. Hesitation, a sign of perceiving risk, was not observed very often. Similarly, most participants were not observed to change speed while crossing, i.e. less than a tenth accelerated, although a fifth were seen to decelerate.

Table 8. Observed crossing behaviours, overall and by crossing choice

	Crossing Behaviours						
	Gap < 10m	Inattention	Hesitation	AV Lane Only	No Change	Acc.	Dec.
Overall (N = 66)	74%	17%	15%	47%	71%	9%	20%
By Crossing Choice:							
Crossed in Front (n = 32)	53%	22%	9%	41%	72%	19%	9%
Crossed Behind (n = 27)	96%	15%	19%	56%	70%	0%	30%
Waited (n = 7)	86%	0%	29%	43%	71%	0%	29%

Note: Acc. = Acceleration; Dec. = Deceleration

During observed crossing interactions, participants most frequently chose to cross in front of an approaching pod (48%) rather than cross behind it (41%) or wait for the pod to pass first before crossing (11%). This risky crossing choice was found to be significantly associated with gap acceptance (χ^2 (2) = 14.81, p < .001), i.e. participants were less likely to cross in front of an approaching pod when the gap to that vehicle was fewer than 10 metres. It was also significantly associated with an observed change in speed (χ^2 (4) = 9.74, p = .045); in other words, participants were more likely to accelerate when crossing in front of an approaching pod. No significant associations were detected between crossing choice and observed inattention (χ^2 (2) = 2.09, p = .351), hesitation (χ^2 (2) = 2.09, p = .351), or the number of lanes crossed (χ^2 (2) = 1.36, p = .506).

3.2.2 Crossing Interactions – Relationships with Other Factors

Although males were more frequently observed to cross in front of an approaching pod than females, with the latter group more often choosing to cross behind the vehicle, this difference was not found to be significant (χ^2 (2) = 3.48, p = .176). Likewise, participants' crossing choices were not significantly associated with their age (χ^2 (4) = 3.91, p = .418), or with the size of group they were travelling in (χ^2 (4) = 2.59, p = .629). It is perhaps worth noting, however, that the choices of participants in groups of two did not follow the same pattern as the choices of the (few) participants in larger groups, who chose more similarly to participants travelling alone (see Table 9).

Table 9. Observed crossing choice, gap acceptance and change of speed by groups

	Crossing Choice			Gap	Change of Speed		
	Crossed in Front	Crossed Behind	Waited	< 10m	No Change	Acc.	Dec.
By Gender:							
Male (n = 45)	56%	33%	11%	73%	76%	9%	16%
Female (n = 21)	33%	57%	10%	76%	62%	10%	29%
By Age:							
Young Adult (n = 14)	57%	43%	0%	79%	86%	7%	7%
Adult (n = 48)	44%	42%	15%	75%	69%	10%	21%
Older Adult (n = 4)	75%	25%	0%	50%	50%	0%	50%
By Group Size:							
Alone (n = 48)	52%	38%	10%	75%	73%	8%	19%
2 (n = 13)	31%	54%	15%	62%	62%	15%	23%
3+ (n = 5)	60%	40%	0%	100%	80%	0%	20%

Note: Acc. = Acceleration; Dec. = Deceleration

Moreover, no significant associations were found between gap acceptance and gender (χ^2 (1) = 0.61, p = .805), age (χ^2 (2) = 1.38, p = .501), or group size (χ^2 (2) = 2.85, p = .241). Similarly, changes in speed were not significantly associated with gender (χ^2 (2) = 1.61, p = .447), age (χ^2 (4) = 4.24, p = .375) or group size (χ^2 (4) = 1.39, p = .845).

As for communication during crossing interactions, while participants were seen to look in the direction of the approaching pod in the majority of cases, at no point was anyone observed making an explicit attempt to communicate with it or its occupants either via hand gestures or by moving up close and peering into the pod. However, one participant was observed stopping to take a photograph of the pod as it went on its way.

At no point during the observations of crossing interactions was a road user seen to be involved in a collision, whether minor or more severe, with a pod (or indeed with any other road user).

3.2.3 Baseline Shared Lane Behaviours

When looked at overall (see Table 10), the most frequent baseline behaviour was for participants to travel in the middle of the shared lane, or spread across it. When participants travelled along one side of the lane, there was no obvious preference for the left or right.

Tests revealed that baseline behaviours in the shared lane differed significantly by road user (χ^2 (4) = 14.32, p = .006) and group size (χ^2 (4) = 94.72, p < .001). That is, joggers were less likely to be found travelling in the middle/spread across the lane while cyclists were less likely to be found travelling on the right. Tests also showed that participants travelling alone were more likely to be on one of the sides of the lane while those in groups were more likely to be in the middle/spread across, especially so if in larger groups. Baseline behaviours did not differ significantly by gender (χ^2 (2) = 3.17, p = .205) or age (χ^2 (4) = 5.41, p = .248).

However, the spatial characteristics of the left and right of the lane differed depending on the direction of travel. That is, when travelling in the direction of John Harrison Way, the left was along the Thames side; although this side did have several obstructions (e.g. barriers surrounding the pier entrance, bushes, concrete blocks), behind these obstructions and partially visible was a wide walkway and view over the Thames river – thus, it could be perceived as a more open space. In contrast, travelling on the right meant travelling alongside tall hoarding, behind which was a construction site. So, the right could be perceived as a more closed-in space when travelling in the direction of John Harrison Way. The spatial characteristics of the left and right were of course reversed when travelling in the direction of the hotel.

Table 10. Baseline behaviours, overall and by road user, gender, age, group size

	Baseline Behaviours			Adjusted Baseline Behaviours		
	Kept Left	In Middle/ Spread Across	On Right	Thames Side	In Middle/ Spread Across	Hoarding Side
Overall (N = 238)	21%	55%	23%	32%	55%	13%
By Road User:						
Pedestrian (n = 198)	19%	58%	24%	32%	58%	11%
Jogger (n = 23)	39%	26%	35%	43%	26%	30%
Cyclist (n = 17)	29%	71%	0%	12%	71%	18%
By Gender:						
Male (n = 133)	24%	50%	26%	34%	50%	16%
Female (n = 105)	18%	62%	20%	29%	62%	10%
By Age:						
Young Adult (n = 54)	13%	59%	28%	30%	59%	11%
Adult (n = 162)	25%	52%	22%	33%	52%	15%
Older Adult (n = 22)	14%	68%	18%	27%	68%	5%
By Group Size:						
Alone (n = 92)	38%	17%	45%	58%	17%	25%
2 (n = 103)	14%	73%	14%	21%	73%	6%
3+ (n = 43)	5%	95%	0%	0%	95%	5%

To adjust for the varying spatial characteristics according to the direction of travel, the “Keep Left” and “On Right” baseline behaviours were re-coded as appropriate into “Thames Side” and “Hoarding Side”. While the overall tendency remained to travel in the middle of or spread across the lane, it now appeared that there might be a bias towards the more open Thames side when participants did travel along one of the sides of the lane.

Once again, tests showed that the (now-adjusted) baseline behaviours in the shared lane differed significantly by road user (χ^2 (4) = 14.11, p = .007) and group size (χ^2 (4) = 95.31, p < .001) but not by gender (χ^2 (2) = 3.69, p = .158) or age (χ^2 (4) = 3.07, p = .546). As before, participants would most often travel in the middle of or spread across the lane unless they were joggers or travelling alone. The figures in Table 10 show that the side most often used by joggers and lone travellers was the Thames side, irrespective of whether that was on the left or the right.

3.2.4 Passing Interactions

While the most common behaviour when pods were not present was for road users to use the space available in the lane, during passing interactions a different picture emerged: As Table 11 shows, when passing or when being passed, the majority of road users either kept to a side or moved to a side, letting the AV continue on its path. A significant association between orientation and approach (χ^2 (4) = 30.76, p < .001) revealed that such behaviour was more likely in head-on encounters with a pod, but when a pod approached the road user from behind, participants were more likely to remain in place.

There appeared to be a bias to orient to the right side of the lane. However, when this behaviour was adjusted for the direction of travel, it became apparent that the side being preferred was actually the seemingly more open Thames side (see Table 11). The percentage of participants orienting to this side during passing interactions was more than double that observed when pods were not present.

Table 11. Orientation during passing interactions, overall and by approach

	Orientation			Adjusted Orientation		
	Kept/Moved Left	Remained in Place	Kept/Moved Right	Kept/Moved Thames Side	Remained in Place	Kept/Moved Hoarding Side
Overall (N = 239)	25%	7%	68%	81%	7%	12%
By Approach:						
Head-On (n = 169)	30%	5%	65%	82%	5%	14%
Behind AV (n = 37)	16%	0%	84%	89%	0%	11%
AV Behind (n = 33)	9%	27%	64%	70%	27%	3%

A further test using the adjusted data again revealed a significant association between orientation and approach (χ^2 (4) = 26.33, $p < .001$), with participants being more likely to remain in place when a pod approached from behind.

Table 12. Change of speed during passing interactions, overall, by approach and orientation

	Change of Speed		
	No Change	Acceleration	Deceleration
Overall (N = 264)	71%	2%	27%
By Approach:			
Head-On (n = 173)	74%	1%	25%
Behind AV (n = 37)	89%	3%	8%
AV Behind (n = 54)	50%	6%	44%
By Orientation:			
Kept/Moved Left (n = 173)	72%	0%	28%
Remained in Place (n = 37)	59%	0%	41%
Kept/Moved Right (n = 54)	75%	4%	21%
By Adjusted Orientation:			
Kept/Moved Thames Side (n = 194)	73%	3%	24%
Remained in Place (n = 17)	59%	0%	41%
Kept/Moved Hoarding Side (n = 28)	82%	4%	14%

Approach was also significantly associated with a change of speed during passing interactions (χ^2 (4) = 20.27, p < .001). That is, participants were more likely to decelerate (slow down and/or stop completely) when being passed by a pod approaching from behind (see Table 12). While deceleration most often occurred when participants remained in place during passing interactions, the frequency of such behaviour was not found to be significantly different to when participants kept or moved to the left/right (χ^2 (4) = 6.58, p = .160) or to the Thames/hoarding side (χ^2 (4) = 4.49, p = .343).

3.2.5 Passing Interactions – Relationships with Other Factors

Table 13. Orientation by road user, gender, age, group size

	Orientation			Adjusted Orientation		
	Kept/Moved Left	Remained in Place	Kept/Moved Right	Kept/Moved Thames Side	Remained in Place	Kept/Moved Hoarding Side
By Road User:						
Pedestrian (n = 194)	24%	8%	68%	81%	8%	11%
Jogger (n = 22)	30%	4%	65%	91%	4%	4%
Cyclist (n = 23)	27%	0%	73%	73%	0%	27%
By Gender:						
Male (n = 166)	29%	7%	64%	80%	7%	14%
Female (n = 73)	16%	8%	75%	85%	8%	7%
By Age:						
Young Adult (n = 52)	25%	10%	65%	85%	10%	6%
Adult (n = 171)	25%	6%	69%	80%	6%	13%
Older Adult (n = 16)	31%	6%	63%	81%	6%	13%
By Group Size:						
Alone (n = 151)	26%	2%	72%	83%	2%	15%
2 (n = 45)	36%	11%	53%	82%	11%	7%
3+ (n = 43)	12%	21%	67%	74%	21%	5%

Group size was significantly associated with orientation (χ^2 (4) = 25.05, p < .001), i.e. participants were more likely to remain in place during passing interactions when in groups of three or more people and less likely when travelling alone (see Table 13). In contrast, no significant association was found between orientation and road user (χ^2 (4) = 2.63, p = .622), gender (χ^2 (2) = 4.21, p = .122) or age (χ^2 (4) = 0.99, p = 911). The pattern of results was the same when using the adjusted orientation data: i.e. a significant association with group size (χ^2 (4) = 22.83, p < .001) but not with road user (χ^2 (4) = 8.39, p = .078), gender (χ^2 (2) = 2.49, p = .288) or age (χ^2 (4) = 2.70, p = .609).

Table 13. Change of speed, by road user, gender, age, group size

	Change of Speed		
	No Change	Acceleration	Deceleration
By Road User:			
Pedestrian (n = 218)	67%	2%	31%
Jogger (n = 23)	91%	0%	9%
Cyclist (n = 23)	91%	4%	4%
By Gender:			
Male (n = 183)	73%	2%	25%
Female (n = 81)	68%	2%	30%
By Age:			
Young Adult (n = 52)	58%	4%	38%
Adult (n = 191)	76%	2%	21%
Older Adult (n = 21)	57%	0%	43%
By Group Size:			
Alone (n = 161)	89%	2%	9%
2 (n = 55)	51%	2%	47%
3+ (n = 48)	35%	4%	60%

Group size was also significantly associated with a change of speed during passing interactions (χ^2 (4) = 67.46, p < .001). In this case, lone travellers were less likely to change their speed and decelerate (see Table 13). Other significant associations with a change of speed were found for road user (χ^2 (4) = 12.60, p = .013) and age (χ^2 (4) = 10.47, p = .033). That is, pedestrians, young adults and older adults were all more likely to change their speed and decelerate during passing interactions. Gender was not significantly associated with a change of speed (χ^2 (2) = 0.63, p = .731).

Regarding communication with a pod and/or its occupants, only two participants were observed to make an explicit attempt at this during passing interactions. In the first case, the participant was a young male pedestrian, travelling alone, who was approached from behind by a pod. The participant remained in place in the middle of the lane, forcing the pod to first slow, then attempt to move round past him. However, the participant remained in the way, thus the pod had to continue at a slow pace behind him. Eventually, the participant aimed a rather hostile gesture and verbal exclamation towards the pod before moving slightly to the right (Thames side), allowing the pod to finally pass.

In the second instance of a communication attempt, the participant was also a lone male pedestrian, although an adult rather than a young adult. He initially approached from head-on but moved out of the lane before the pod fully entered the interaction zone. He stared into the pod as it passed along the lane, then re-entered the lane and followed behind, catching up with the vehicle when it slowed for another road user up ahead. The participant then moved round to the right of the pod (Thames side) and practically pressed his face up against its door, forcing the pod to stop completely. This was not a hostile gesture; on the contrary, the participant seemed delightedly fascinated with pod. It was not possible from the coder's vantage point to see how the passengers inside the vehicle reacted to this participant's behaviour.

Other participants were observed to look at the pods but these were usually cursory glances or, if longer stares, happened after the pod had passed. The latter behaviour suggested that either it took a moment for these participants to comprehend that the pod was an AV or their priority was to move out of the way of the pod, only stopping to take a proper look at the vehicle once clear of it. Following five passing interactions, participants were seen taking photographs of the pod.

Lastly, at no point during the passing interactions were any collisions (whether minor or more severe) observed occurring between road users and pods or between road users and other road users.

4 Discussion

4.1 Survey Data

Findings from previous survey research (e.g. Bansal, Kockelman & Singh, 2016; Kyriakidis, Happee & de Winter, 2015; Schoettle & Sivak, 2014) suggest that many people recognise the potential for AVs to reduce the incidence of road traffic collisions in public areas, thereby making these areas safer for road users, particularly vulnerable road users such as pedestrians. One UK survey (Smith, 2016) suggested otherwise. In the current research, responses from almost 1000 members of the UK public to the pre-trial survey indicated that this sample did see AVs as a safer mode of transport. That is, when answering from the perspective of a pedestrian travelling in the vicinity of vehicles, participants rated the perceived risk to them as significantly lower when those vehicles were imagined to be AVs compared to when they were imagined to be conventional cars. However, when participants were answering from the perspective of a passenger, they perceived themselves to be at significantly greater risk if the vehicle they were travelling in were an AV than if it were a conventional car. This finding highlights that if survey studies focus solely on users of AVs – as most have, to date – their findings may not necessarily reflect the perceptions of the public at large.

Nevertheless, whether from the perspective of a passenger or a pedestrian, participants in the pre-trial sample tended to rate AVs on the low end of the perceived risk scale ("somewhat low risk"), in contrast to other objectively risky modes of transport such as motorcycles. The AV risk ratings were not quite as low as that for other automated transport already in mass use (e.g. the DLR), suggesting that participants recognise that the public roads are a more complex setting than railway tracks from which other road users are excluded. This result could also reflect the fact that AVs were an unknown or unproven quantity for this pre-trial sample. Nevertheless, the mean risk ratings indicated that, overall, AVs were not perceived to be a particular threat to participants' safety.

A considerable number of participants (43%) in the pre-trial sample also displayed positive or conditionally positive attitudes towards the prospect of AVs on the public roads, suggesting that they were, overall, accepting of this future development. However, the caveats stated from among those selecting “conditionally positive”, along with the finding that a slightly larger number of participants (46%) reported being “uncertain” about AVs, showed that several concerns existed within this sample. This is consistent with the previous survey research (Bansal, Kockelman & Singh, 2016; Kyriakidis, Happee & de Winter, 2015; Schoettle & Sivak, 2014; Smith, 2016), where participants have displayed several concerns, often with regards to possible system or equipment failures. In the current research, the pre-trial sample also appeared concerned about failures, with statements expressing a need for safety testing to be thorough, regulated and/or demonstrated.

The research trial at the Greenwich Peninsula provided a good opportunity to examine general attitudes, and risk perceptions, following a real-life demonstration of AVs in action in a public space. The perceived risk ratings the Trial 1 survey participants gave for the driverless pods (“extremely low risk”) tended to be lower not only than the ratings given by the pre-trial sample for AVs but also lower than the ratings given by that sample for existing driverless trains. This favourable impression was reinforced by the general attitudes revealed: 84% of participants in the Trial 1 sample displayed positive or conditionally positive attitudes towards the prospect of AVs. In other words, compared to participants who had not yet experienced an AV, those that had experienced one were almost twice as likely to display acceptance of AVs being on the public roads in the future. Moreover, the percentage of Trial 1 participants reporting they were “uncertain” was less than a quarter of that reporting such an attitude in the pre-trial sample. Therefore, these findings suggest that being able to see and even ride in an AV may have removed some concerns for the public.

It is important to reiterate that the majority of Trial 1 surveys completed to date were from members of the public who had travelled as passengers in a pod. The low number of surveys from people who had encountered the pods while on foot at the Peninsula preclude any inferential statistical test from being run to compare perceived risk and attitudes across these two road user groups. However, descriptive statistics show that the current median perceived risk rating from pedestrians was low but not quite as low as that of passengers ("moderately low risk" vs. "extremely low risk", respectively) – an outcome contrary to that hypothesised. If this pattern of responding were to remain with larger and more equal sample sizes, and be significantly different, then it would indicate that the demonstration may have assuaged some safety concerns related to travelling inside an AV (for example, system and equipment reliability) but perhaps raised new questions for those travelling outside of one. Despite this, all of the participating pedestrians displayed "positive" and "conditionally positive" attitudes, suggesting that, more generally, they remain open to the prospect of AVs.

4.2 Observational Study Data

It was hypothesised that pedestrians would be more likely to choose to cross in front of an AV rather than cross behind it or wait, on the basis that they would expect AVs to be programmed to avoid collisions and thus yield to them. The observations of crossing interactions supported this hypothesis, with the most frequent crossing choice being to cross in front of an approaching driverless pod (48%). The next most frequently observed choice was to cross behind an approaching pod (41%), with only around a tenth of participants in these interactions choosing to wait until the oncoming pod had passed before advancing.

While the above finding demonstrated that participants were commonly *taking* more risks when crossing in the vicinity of the AVs, other behaviours suggested that they nevertheless *perceived* such behaviours to be risky. Firstly, the low frequency of inattention observed demonstrated that participants were most often aware that there was an oncoming vehicle present. Furthermore, participants were significantly less likely to cross in front of an approaching pod if it was within 10 metres of them. Ten metres was established as a gap that could be judged as a safety threshold: i.e. given the pod's speed, the width of the AV lane, and the average crossing speed for a pedestrian, any gap smaller than 10 metres could possibly result in the pod and pedestrian colliding,. This distance gap of 10 metres equates to a time gap of approximately 3 seconds in this particular scenario, which is a common minimum accepted gap reported in literature on crossing interactions between pedestrians and conventional road traffic (Chandra, Rastogi & Das, 2014). Thus, it would appear that while participants in Trial 1 were frequently displaying relatively risky crossing behaviours around the AVs by choosing to cross in front of pods, they nonetheless underwent “normal” processes to arrive at this choice and were therefore not being unduly careless or reckless. Note, that while over half of participants crossed not just the AV lane but also the pedestrian/cyclist lane, the latter lane did not contain any faster moving road users during these interactions (i.e. no other motorised vehicles nor any cyclists who, when they were seen in the crossing interaction zone, used the AV lane). So it is likely that participants’ crossing choices were based just on the width of the AV lane.

A gap smaller than 10 metres to the approaching AV could have resulted in a collision if neither party involved in the crossing interaction were to change their speed in the meantime. In fact a change of participant speed was noted on occasion (more than a quarter of all crossing interactions) and this behaviour, more specifically an *increase* in crossing speed, was observed significantly more often when participants chose to cross in front of an approaching pod. This again suggests that these participants did undergo some form of risk perception and assessment and modified their behaviour accordingly. Moreover, it has been observed in crossing interaction studies with conventional road traffic that pedestrians tend to increase their speed after making more risky choices (Chandra, Rastogi & Das, 2014). Thus, once again, the sample observed during Trial 1 appeared to be reacting to the AVs in similar ways to which pedestrians do with human-operated vehicles.

A useful next step would be to test AVs in a crossing location that afforded a direct comparison with human-operated motorised vehicles (or an area with a larger volume of cyclists). Then it could be more definitively ascertained if participants react to AVs in a “normal” way when crossing or if, due to perceiving them as relatively low risk forms of transport, they feel emboldened around AVs and therefore display comparatively more risky crossing behaviours when interacting with them. The fact that instances of hesitation were observed only infrequently (regardless of crossing choice) could be seen to support the idea that participants were operating under an automatic assumption of relative safety around AVs and spent no additional time processing and attempting to first predict how the vehicle might behave. However, it could also suggest that AVs were not seen by participants as a different category of vehicle to conventional cars but simply categorised as a vehicle, i.e. another example of a road user that is somewhat larger and faster moving than the participant. The fact that it was not being operated by a human may not have been factored into the decision-making process.

What was "normal" in the passing interactions had to first be established by observing baseline behaviours when the driverless pods were not present, given the passing interaction zone was a shared space and thus it was not known if participants would typically be travelling along the sides of the space or in the middle/spread across it. The baseline observations showed that, most frequently, road users did tend to move more freely in the space, typically being found travelling in the middle of the lane. This behaviour was significantly more common when road users were travelling in groups, a finding consistent with another UK study of shared spaces (Atkins, 2012). This finding is also intuitive, as spreading out into the middle of the lane would allow group members to more easily see and hear one another, thereby facilitating conversations and other interactions, which would be difficult if they travelled in single file behind one another.

Travelling in the middle of or spread out across the shared lane was significantly less common when the road users travelling on foot were jogging rather than walking. The data did not suggest however that, when joggers travelled to one side in the absence of pods, they were adhering to the "keep left" maxim for more conventional road user situations. While cyclists were most often found using the middle of the lane, when they did keep to a side, it was significantly less likely to be the right side, suggesting perhaps that this road user group were more mindful of this maxim. However, the spatial characteristics of the left and right sides differed depending on the direction of travel. When baseline behaviours were adjusted for this, the overall tendency to travel in the middle/spread across the lane was not affected but a bias towards the Thames side – a seemingly more open space – did appear to emerge when a road user was found travelling on one side. The exception was cyclists, who would slightly (but not significantly) more often use the opposite hoarding side. This behaviour could reflect habit; at both ends of the passing interaction zone, the route splits back into two lanes and, prior to pods being introduced to the area, the lane for cyclists was the one on the inside, so they may have been used to this orientation.

The observations of passing interactions revealed that road users' use of the shared space was modified when AVs were present. The majority of participants (93%), when passing or when being passed, either kept to or moved to a side, letting the pods continue on their path. This was particularly the case when participants and pods approached one another head-on. An earlier UK study (Moody & Melia, 2014) also reported that the majority of pedestrians (72%) were observed to initially yield during interactions with conventional traffic in a shared space. Thus, despite such space being designed to lower the dominance of motorised vehicles, it would appear that such dominance is still perceived to exist. Moreover, *motorised* would seem to be one of the key elements as 100% of cyclists were also observed to keep or move to the side out of the way of pods in Trial 1 passing interactions.

Significantly less likely to yield and instead remain in place were participants travelling in groups of three or more people. It is possible that this simply reflects the fact that in a single lane more people will necessarily take up more space and thus find it harder to move out of the way even if they wished to. Alternatively, it could suggest that participants in large groups see themselves as a collective, and therefore greater, mass rather than individuals moving in close proximity and thus perceived themselves as being on more equal terms with the pod. Future studies should aim to examine passing interactions with AVs in road settings of varying widths to see whether the effect of group size remains when there is physically more space available for larger groups to yield.

Participants were also significantly less likely to yield when they were approached by a pod from behind. It would seem in these cases where participants did remain in place, this behaviour was driven more by a lack of awareness of the pod's presence than by an assertive sense of having equal (or greater) priority in the shared space. Research has demonstrated how people may use auditory cues as well as visual ones to detect and react to other road users (Barton, Ulrich & Lew, 2012). In these passing interactions where participants were approached by a pod from behind, they lacked the ability to not only see the pods but likely also hear the pods given that they were electric and thus moved rather quietly. When the pods did make more noise (i.e. eventually sounded their horn after slowly moving for some time behind participants remaining in place), participants were observed to move quickly out of the way. In one such instance, the participant (a female young adult pedestrian pushing a child in a buggy) was wearing in-ear headphones, thus likely exacerbating her inability to be aware of the pod's presence. However, it was noted that when she did move after hearing the horn, her behaviour did not suggest she was startled or surprised so it is not conclusive that she had been unaware of the pod prior to that. The significant association between being approached from behind by a pod and changing one's speed (i.e. slowing and/or stopping) would suggest that, on the other hand, quite a number of participants in these situations were startled or surprised and changed pace in order to fully attend to and process what they had encountered.

At no point during these approaches from behind did the participants appear in any danger; the pods always modified their speed accordingly when a participant did not yield and the horn sound was short and light, not long and loud, thus did not appear to be construed as an aggressive gesture. Such passing interactions could consequently be judged as safe and satisfactory. However, once AVs have a more regular and therefore anticipated presence in areas with pedestrians and other vulnerable road users, it remains to be seen what their behaviours will be. That is, will these vulnerable road users continue to most often yield for the AVs except for when unaware of their presence or will road users become more assertive, feeling comfortable to continue travelling in the middle of/spread across shared spaces and remain in place when encountering pods, having learned the pods will initially yield instead if they do not? Future research trials should be conducted over longer periods to assess the effect of familiarisation over time on pedestrian behaviour. Even if more assertive, unyielding behaviour from pedestrians travelling alone or in small groups were to emerge and have no impact on safety, it could impact the smooth running of AVs if they were to constantly slow down and/or stop for others, which in turn could impact people's willingness to use AVs as a means of passenger transport. Research should also conduct comparisons between interactions involving electric AVs and electric human-operated cars to tease apart the factors influencing road users' reactions to them.

Despite the passing interactions taking place relatively smoothly overall, with no collisions actually occurring, there was still a sign that participants perceived some level of risk, even if small, when encountering the pods. That is, a large percentage of participants (81%) opted to keep or move to the Thames side when passing or being passed. As mentioned several times earlier in this report, this side of the lane was seemingly more open space. Therefore, a bias towards such space during AV passing interactions suggests road users were cautious to a certain extent, putting themselves in a position where they could possibly get further away from the pod if they needed to. Although a preference for travelling on the Thames side was observed under pod-absent conditions also, when participants deviated from the norm and travelled on one of the sides rather than in the middle of or spread out across the lane, the percentage of participants doing so then was far lower (32%). However, the fact that the majority of participants did not display a change of speed (acceleration or deceleration) once the passing interaction had begun, indicates that any initial caution may have quickly subsided.

The rarity or even non-existence of communication attempts, during passing and crossing interactions respectively, supports the idea that participants quickly came to be more comfortable around and/or predict the pod's behaviour. An earlier exploratory study (Rothenbücher, Li, Sirkin, Mok & Ju, 2016) had shown signs that explicit attempts at communicating with AVs might be uncommon. Research with other types of vehicles (including bicycles) has revealed that, in the absence of human facial or bodily cues, road users may instead use cues from the vehicle itself, such as its positioning, to infer intention (Walker & Brosnan, 2007). Thus, the inability to see a human operator's face, or indeed any vehicle occupant's face given the seating configuration of the pods, and therefore communicate with them did not appear to pose problems for those travelling outside of the vehicle.

4.3 Socio-Demographic Factors and Individual Differences

Consistent with previous survey research on public perceptions of AVs (Bansal, Kockelman & Singh, 2016; Kyriakidis, Happee & de Winter, 2015; Schoettle & Sivak, 2014; Smith, 2016), the pre-trial survey data showed gender differences. That is, females gave significantly higher perceived risk ratings for AVs and males were significantly more likely to display a positive attitude towards the prospect of AVs on public roads. However, gender differences were not found consistently in the Trial 1 data. Females did not give significantly different perceived risk ratings to males (and the ratings they gave were actually *lower* in general than males' ratings). Males in Trial 1 did however display significantly more positive attitudes than females. Thus, it would seem that factors other than risk, or more prominently than risk, were influencing males and females' acceptance or otherwise of the prospect of AVs. This is further supported by the general lack of any significant relationships found between age, risk-taking and perceived risk or general attitudes (with the exception of in the pre-trial survey data, where younger adults displayed significantly more positive attitudes and older adults significantly more negative attitudes). Males and younger adults have typically been found to engage more in taking road user risks and therefore perceive less risk in this domain (e.g. Turner & McClure, 2003). It has been hypothesised that they would therefore differ in their perceptions of AVs, regarding the vehicles as posing less risk of physical harm but being risky, and therefore exciting and to be embraced, in the sense of being a new technology (see Hulse, Xie & Gales, 2018). However, it would appear that, prior to the trial, AVs were too much of an unknown quantity to form any perception of their risk then and, following the trial, all participants saw them as a relatively safe form of transport, thus no differences were found relating to risk of physical harm.

Likewise, once the AVs had been experienced in person, it may be that the sense of a new, unexplored technology diminished and consequently so did the previously seen age effects.

Significant associations with gender and age were little seen in the Trial 1 observational study either. The only significant relationship found between a socio-demographic factor and behaviour was during passing interactions where young adults and older adults, compared with adults, were both more likely to change their speed and decelerate. This could in part be related to the fact that both these groups' tend to move at more obviously different speeds in general, i.e. younger people tend to walk faster and older people tend to walk more slowly (Ishaque & Noland, 2008), thus any change in speed in these groups might have been more noticeable to coders under direct observation. It is possible that using more precise techniques to measure speeds (e.g. video observation) could uncover subtle but significant changes in speed in adults also. The failure to observe any changes of speed related to age in the crossing interactions may be because the distance covered in the crossing interactions (often just 3.3 metres, the width of the AV lane) was considerably shorter than the distance covered by road users during the passing interactions. Therefore, there may have been less opportunity for any age-related changes of speed to occur or be noticed. Moreover, it should be noted the number of young and older adults in the crossing interactions was relatively small.

One surprising finding was that in the Trial 1 survey, drivers displayed more positive attitudes and fewer conditionally negative attitudes than did non-drivers. This could be related to the fact that the trial took place in a shared space previously dedicated to pedestrians and cyclists and thus were seen as an alternative means of transport to be used in such spaces. For drivers then, they did not appear to be replacing conventional cars (yet) while for non-drivers they may have been seen as potentially replacing cycling or walking and therefore more of a threat to their favoured means of travel. The stated caveats accompanying the "conditionally positive" (and "conditionally negative") attitudes would support this idea.

4.4 Limitations

While the pre-trial survey sample size was large, the Trial 1 survey sample size was much smaller. This is in part to be expected given that the former could be completed by anyone while the latter relied on people having actually been to the Peninsula during the four weeks of the trial. As the pods were only running during daytime hours on weekdays this meant that many of the people to whom the trial and survey was advertised (e.g. university staff and students) were unable to act on the invitation. Moreover, the wish to avoid competing with other surveys being run concurrently for the research project, or causing survey fatigue in the target population, meant that other recruitment activities were limited and conducted in stages. This means that firm conclusions cannot yet be drawn on pedestrian perceptions of AVs following direct experience with such vehicles, although the small number of surveys received and analysed to date from pedestrians provided a consistent picture. The lack of representation of the perspectives of pedestrians, and other vulnerable road users, in AV survey studies in general is something which must continue to be addressed by the research community as a whole to ensure that the reported findings do reflect that of the wider public and not just regular drivers or passengers.

The sample size for the observed crossing interactions was also somewhat small. This was due to several factors. First, the timing of the trial in winter – and particularly given the snowy weather just days before the trial launch – meant that footfall at the trial site was lower than when site feasibility visits took place in the previous summer. Fewer users of the Thames Path overall meant fewer people crossing overall. Combined with the fact that the number of pods in the fleet and operating at any one time was also small, this meant that occasions where pedestrians and pods were both approaching the crossing interaction zone at the same time were less frequent than desired. Additionally, for several days during the trial, some fencing was erected and large trades' vehicles parked on the access road leading to the junction by the crossing point. This gave the (false) impression that there was no through access for the public to the Thames Path via the junction. Thus, again, footfall was impacted. As such, the current sample size precludes more in-depth statistical analysis of the crossing interaction data (e.g. testing for interaction effects) and this must be borne in mind when considering the results.

As the area for the passing interactions was a shared space it provided the opportunity for direct interactions involving AVs, people on foot, and people on bicycles, to actually be observed. However, it also meant that the findings cannot be generalised beyond shared spaces to more conventional road spaces. This limitation also applies to the crossing interactions: while the crossing point did intersect a two-lane path near a junction (therefore, quite a common setting for such research), the only other road users were again people on foot or on bicycle. With no conventional motorised vehicles regularly running through the area, the trial site did not represent a typical road space. Moreover, the vehicle speed involved in the crossing and passing interactions is much lower than the speeds typically seen in conventional road spaces in urban areas. So, the objective level of risk posed to participants would have been lower, which may have influenced the self-reports of perceived risk and the actual behaviours observed.

Despite these limitations, the various strands of research combine to provide insight on perceptions of, and behaviours around, AVs. The answers to the additional question in the Trial 1 survey, on whether the trial had impacted participants' perceptions of AVs, indicated that the interactive demonstration had been reasonably successful, with most responses pointing to pre-existing positive perceptions being retained or reinforced. Where perceptions were changed, this happened in a positive direction more than a negative direction, although the fact that some participants did now feel less positive about AVs suggests that the trial raised new questions or concerns for them. The stated caveats to the "conditionally positive" and "conditionally negative" attitudes indicate that these questions and concerns may relate specifically to AVs being introduced in space primarily designed to reduce dominance of motorised vehicles. Meanwhile the observations of direct interactions between vulnerable road users and AVs, and the fact that the interactions were uneventful in terms of collisions or (with one exception) signs of hostility towards the pods, indicate that they nevertheless were all able to share the space quite safely. The challenge going forward for automotive and technology companies then, as well as those organisations and authorities facilitating their developments, will be to ensure that this current encouraging position and momentum is not lost when AVs are introduced to even more complex public spaces (e.g. ones where other motorised vehicles are also present).

5 Conclusion

From the original research reported here, it can be seen that participants have rather favourable perceptions of AVs (small, road-based automated passenger vehicles). That is, AVs were perceived as posing a low risk to the road users surveyed. Perceived risk ratings were even lower for participants for whom AVs were a more tangible phenomenon rather than just a hypothetical one, i.e. they had actual experience of interacting with an AV. Likewise, participants (whether passengers or pedestrians) displayed attitudes that suggested many accepted the prospect of AVs being on the public roads in the future. While the pre-trial sample nevertheless expressed some considerable uncertainty, the sample engaged in Trial 1 showed little sign of this, expressing largely positivity.

Some of the observed behaviours supported the idea that AVs were perceived as low risk, for example with the majority of participants involved in crossing interactions choosing to cross in front of an approaching AV rather than behind or waiting for it to fully pass first. However, other crossing behaviours suggested that participants were not behaving more carelessly or recklessly around these vehicles than they would around conventional cars. Moreover, several of the behaviours observed during passing interactions, including the increased bias to keep or move over to the more open Thames side, suggested that participants were displaying some caution, at least initially, during these interactions. Some other behaviours showed less yielding from participants. However, the results of the observational study, combined with the stated caveats from the Trial 1 survey, suggest that this caution or lack of yielding on occasion may have had less to do with the vehicle being driverless and more to do with other factors that may exist already in certain settings (e.g. motorised vehicles using shared spaces) or with certain types of vehicle (e.g. electric ones). Thus, when considering the next step for testing and integrating AVs into public environments, policymakers and other facilitators may wish to consider some of the existing issues being raised from other schemes that were designed to reduce the public's reliance on cars and improve road safety for vulnerable road users and road users as a whole.

6 References

- Bainbridge, W.A., Isola, P., & Oliva, A. (2013). The intrinsic memorability of face images. Journal of Experimental Psychology: General, 142(4), 1323-1334.
- Bansal, P., Kockelman, K.M., & Singh, A. (2016). Assessing public opinions of and interest in new vehicle technologies: an Austin perspective. Transportation Research Part C: Emerging Technologies, 67, 1–14.
- Barton, B.K., Ulrich, T.A., & Lew, R. (2012). Auditory detection and localization of approaching vehicles. Accident Analysis and Prevention, 49, 347-353.
- Blais, A.-R., & Weber, E.U. (2006). A domain-specific risk-taking (DOSPERT) scale for adult populations. Judgment and Decision Making, 1(1), 33-47.
- Chandra, S., Rastogi, R., & Das, V.R. (2014). Descriptive and parametric analysis of pedestrian gap acceptance in mixed traffic conditions. KSCE Journal of Civil Engineering, 18(1), 284-293.
- Chang, W.-R., Leclercq, S., Lockhart, T.E., & Haslam, R. (2016). State of science: occupational slips, trips and falls on the same level. Ergonomics, 59(7), 861-883.
- Department for Transport (2007). The Official Highway Code. Available at: https://www.gov.uk/guidance/the-highway-code
- Department for Transport (2011). Local transport note 1/11: shared space. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/ 3873/ltn-1-11.pdf
- Department for Transport (2016). Reported road casualties Great Britain, annual report: 2015. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/568484/rrcgb-2015.pdf
- Dickens, L., Healy, E., Plews, C., & Uthayakumar, K. (2010). Designing the future – shared space: qualitative research. Available at: https://nacto.org/docs/usdg/shared_space_qualitative_research_dickens.pdf
- Gupta, N., Fischer, A.R.H., & Frewer, L.J. (2012). Socio-psychological determinants of public acceptance of technologies: A review. Public Understanding of Science, 21(7), 782-295.
- Hatfield, J., & Prabhakharan, P. (2016). An investigation of behaviour and attitudes relevant to the user safety of pedestrian/cyclist shared paths. Transportation Research Part F: Traffic Psychology and Behaviour, 40, 35-47.
- Hulse, L.M., Xie, H., & Galea, E.R. (2018). Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. Safety Science, 102, 1-13.
- Ishaque, M.M., & Noland, R.B. (2008). Behavioural issues in pedestrian speed choice and street crossing behaviour: A review. Transport Reviews, 28(1), 61-85.
- Kaparias, I., Hirani, J., Bell, M.G.H., & Mount, B. (2016). Pedestrian gap acceptance behavior in street designs with elements of shared space. Transportation Research Record, 2586, 17-27.
- Karndacharuk, A., Wilson, D.J., & Dunn, R. (2014). A review of the evolution of shared (street) space concepts in urban environments. Transport Reviews, 34(2), 190-220.
- Kyriakidis, M., Happee, R., de Winter, J.C.F. (2015). Public opinion on automated driving:results of an international questionnaire among 5000 respondents. Transportation Research Part F: Traffic Psychology and Behaviour, 32, 127–140.
- Moody, S., & Melia, S. (2014). Shared space: Research, policy and problems. Proceedings of the Institution of Civil Engineers – Transport, 167(6), 384-392.
- Rhodes, N., & Pivik, K. (2011). Age and gender differences in risky driving: The roles of positive affect and risk perception. Accident Analysis and Prevention, 43(3), 923-931.

- Rothenbücher, D., Li, J., Sirkin, D., Mok, B., & Ju, W. (2016). Ghost driver: A field study investigating the interaction between pedestrians and driverless vehicles. In: Proceedings of the 25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), New York, USA, August 26-31, 2016.
- Schoettle, B., Sivak, M., 2014. A Survey of Public Opinion About Autonomous and Self-Driving Vehicles in the US, the UK, and Australia. University of MichiganTransportation Research Institute, Ann Arbor, MI.
- Shurbutt, J. (2013). Where pedestrians cross the roadway. Available at: https://www.fhwa.dot.gov/publications/research/safety/13099/13099.pdf
- Smith, M., 2016. Majority of public would be scared to take a ride in a driverless car. London: YouGov. Available at:<https://yougov.co.uk/news/2016/08/26/majoritypublic-would-be-scared-take-ride-driverle/>[Accessed 12 October 2016].
- Turner, C., & McClure, R. (2003). Age and gender differences in risk-taking behaviour as an explanation for high incidence of motor vehicle crashes as a driver in young males. Injury Control and Safety Promotion, 10(3), 123-130.
- Venkatesh, V., Thong, J.Y.L., & Xu, X (2012. Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. MIS Quarterly, 36, 157-178.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27, 425–478.
- Walker, I., & Brosnan, M. (2007). Drivers' gaze fixations during judgements about a bicyclist's intentions. Transportation Research Part F: Traffic Psychology and Behaviour*,* 10 (2), 90-98.
- Willis, A., Gjersoe, N., Havard, C., Kerridge, J., & Kukla, R. (2004). Human movement behaviour in urban spaces: implications for the design and modelling of effective pedestrian environments. Environment and Planning B: Planning and Design, 31, 805-828.
- Zheng, Y., Chase, T., Elefteriadou, L., Schroeder, B., & Sisiopiku, V.P. (2015). Where do pedestrians jaywalk and how do drivers react? A study within a campus environment. In: Proceedings of the 94th Transportation Research Board Annual Meeting, Washington DC, USA, January 11-15, 2015.
- Zhuang & Wu (2011). Pedestrians' crossing behaviors and safety at unmarked roadway in China. Accident Analysis and Prevention, 43(6), 1927-1936.

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