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Perceptions of Autonomous Vehicles: Relationships with Road Users, Risk, Gender and Age

Abstract

Fully automated self-driving cars, with expected benefits including improved road safety, are closer to becoming a reality. Thus, attention has turned to gauging public perceptions of these autonomous vehicles. To date, surveys have focused on the public as potential passengers of autonomous cars, overlooking other road users who would interact with them. Comparisons with perceptions of other existing vehicles are also lacking. This study surveyed almost 1,000 participants on their perceptions, particularly with regards to safety and acceptance of autonomous vehicles. Overall, results revealed that autonomous cars were perceived as a “somewhat low risk" form of transport and, while concerns existed, there was little opposition to the prospect of their use on public roads. However, compared to human-operated cars, autonomous cars were perceived differently depending on the road user perspective: more risky when a passenger yet less risky when a pedestrian. Autonomous cars were also perceived as more risky than existing autonomous trains. Gender, age and risk-taking had varied relationships with the perceived risk of different vehicle types and general attitudes towards autonomous cars. For instance, males and younger adults displayed greater acceptance. Whilst their adoption of this autonomous technology would seem societally beneficial – due to these groups’ greater propensity for taking road user risks, behaviours linked with poorer road safety – other results suggested it might be premature to draw conclusions on risk-taking and user acceptance. Future studies should therefore continue to investigate people’s perceptions from multiple perspectives, taking into account various road user viewpoints and individual characteristics.

Keywords: autonomous vehicle; road safety; pedestrian; risk; gender; age

1. Introduction

The twentieth century witnessed a revolution in passenger transport with the mass production of affordable cars allowing people to drive themselves freely from A to B. In the twenty-first century, technology and automotive companies are working to realise a new passenger transport revolution: fully automated cars, which – by removing the need for a driver – are expected to reduce the number of collisions resulting from human driving error and improve road safety. Although some forms of autonomous vehicles, such as driverless trains (Lo, 2012) and airport shuttles (TRL, 2016), have been in common usage in cities for a number of years, these modes of transport run along enclosed routes and are therefore limited in terms of their movements and interactions with vehicles or people other than passengers. In contrast, autonomous cars will, in theory, be moving amongst other road users along public routes, thus their interactions with people will be, and may be perceived to be, more complex. Some surveys have been conducted in recent years on the public's perception of autonomous cars, but have typically focused on people as users of such vehicles (Bansal et al., 2016; JD Power, 2013; Kyriakidis et al., 2015; Schoettle and Sivak, 2014; Smith, 2016). Perceptions from an external point of view, e.g. as pedestrians in an area with autonomous cars, have received little attention to date. Likewise, there has been little attempt to compare perceptions of autonomous cars with perceptions of other, existing vehicles. This paper reports findings of a survey with participants resident in the UK investigating perceptions of autonomous cars, particularly with regards to road safety and acceptance. Perceptions are compared in relation to road users (i.e. pedestrians as well as occupants of both human-operated and autonomous vehicles), risk (taking and perception), and participant gender and age.

1.1 Road safety

The act of driving is complex. Several motor and cognitive tasks must be performed, sometimes in quick succession, sometimes simultaneously, with drivers having to interact with and react to a variety of vehicular parameters, motorist and pedestrian behaviours, all in varying weather, lighting and road surface conditions. Due to these challenges, it is perhaps not surprising that things can go wrong, and the cost when it does is high. Each year, around the world, approximately 1.25 million people are killed and a further 20 to 50 million injured in collisions, negatively impacting the casualties, their families, employers and, consequently, nations (WHO, 2016). Around three-quarters of these road traffic fatalities are male, while almost half are people aged between 15 and 44 years old.

Human behaviour is a critical factor in road safety (Petridou and Moustaki, 2000). Several forms of road user behaviour have been highlighted as increasing the risk of collisions resulting in casualties. Key risky driving behaviours comprise the consumption of intoxicating substances, travelling at higher average speeds, not wearing protective seat belts or headgear, and distractions, particularly the use of mobile phones (WHO, 2016). Previous research has linked self-reported risky driving behaviour not only with demographic factors, such as male gender and younger age (e.g. Turner and McClure, 2003), but also with individual and personality differences including "sensation seeking", "ego undercontrol" and "present-orientation" (e.g. Zimbardo et al., 1997).

Driving skills, or the lack of them, may also play a role in road traffic collisions. To (attempt to) avoid a collision, a driver must first detect a stimulus, interpret it as a hazard, recognise that action is required, determine an appropriate action, then move to commence the selected action such as braking. The time for this perception and response ("reaction time"), varies depending on situational factors such as expectancy, urgency and cognitive load and possibly also demographic factors such as gender and age (Green, 2000). Further time is then required to carry out the action to its conclusion (e.g. braking to a complete stop). A review by Elander et al. (1993) concluded that, regarding driving skill, the perceptual rather than motor element would appear to be more important regarding collisions, and suggested that advanced training and experience might combat this in part. However, those authors added that risky driving behaviours, given the link with enduring personality traits, might be harder to overcome, at least in the long term. The problem of personality-related risky driving behaviours is further emphasised by studies on driver assistance technology such as anti-lock braking systems (Jonah et al., 2001) and adaptive cruise control (Rudin-Brown and Parker, 2004). While this technology was developed to counter driving skill deficiencies and increase road safety, these studies found suggestive evidence that such technology might in fact heighten risky behaviour from personality types such as sensation seekers.

1.2 Autonomous vehicles

One proposed solution for reducing collisions resulting in casualties is to eliminate the human element from driving; i.e. work towards fully automated passenger cars. These autonomous cars – also referred to as “self-driving” or “driverless” cars – go beyond currently available semi-autonomous models with driver assistance technology. Autonomous cars will, once started up, operate without human intervention, utilising computerised systems to detect and collect information about the environment, identify paths and hazards, as well as control functions such as acceleration and steering, to navigate the vehicle accordingly. Without the need for a human driver, occupants of autonomous cars would become passengers, who could engage in some of the identified key risky behaviours without theoretically posing a threat to themselves or others. Note, autonomous vehicles do not completely remove the human element from driving; people must develop the algorithms and write the code that control them. Thus, human error may still result in collisions and casualties, albeit potentially at a lower incidence rate.

The concept, and practice, of an autonomous vehicle is not a new one. Other forms have existed for several decades. Train examples include the SkyTrain in Vancouver, Canada, the Docklands Light Railway (DLR) in London, UK, and the Yurikamome in Tokyo, Japan (Lo, 2012). While there are anecdotal reports in the media regarding public fears about safety on autonomous trains, hardly any actual studies of public opinion exist in the academic literature. One small survey (N = 50) that does (Fraszczyk et al., 2015) found that the majority of participants were not worried about using a driverless train. This generally positive attitude is reflected in other, non-scientific collections of public opinion (e.g. travel website reviews of the DLR; TripAdvisor, 2016) and in the increasing number of passengers using autonomous rail systems (e.g. Department for Transport, 2016a). More than 1.5 million passengers have also used driverless shuttles such as Heathrow Airport's Ultra pods, which transport people short distances between Terminal 5 and the business car park (TRL, 2016). However, both these autonomous shuttles and the aforementioned trains run on enclosed roadways or tracks, separate from the public roads, and so do not interact with other vehicles or pedestrians. In contrast, autonomous cars would encounter various road users, thereby resulting in complex interactions and the possibility of conflict. Would people therefore be as accepting of autonomous cars as they appear to be of existing autonomous transport?

1.3 Public opinion of autonomous cars

As a growing number of governments take actions to support the testing and production of autonomous cars (Department for Transport, 2015a), attention has turned to gauging public perceptions of these vehicles. Schoettle and Sivak (2014) engaged 1533 participants aged 18 years or older from the UK, USA and Australia in an online survey using SurveyMonkey's Audience tool. The majority of participants thought it somewhat likely that autonomous vehicles would result in both fewer and less severe collisions. However, they also revealed numerous concerns about travelling in autonomous vehicles. Of most concern was system or equipment failures resulting in safety consequences. Furthermore, participants were unanimously very concerned about autonomous vehicles offering no controls for them to take over driving and the thought of other types of road vehicle being autonomous, although the concern seemed to lessen somewhat the smaller the vehicle got (i.e. heavy goods vehicles > buses > taxis). While there were some differences in survey responses according to participant age (e.g. older participants more likely than younger participants to say they would not ride in an autonomous vehicle), gender differences were detected on almost all questions, with females less convinced by autonomous vehicles than males.

Further online surveys have been conducted subsequently with samples of the public in different parts of the world: for example, 347 adults recruited through neighbourhood associations in Austin, USA (Bansal et al., 2016); 1661 adults in Great Britain recruited via internet polling company YouGov (Smith, 2016); and 4886 adults from 109 countries recruited through crowdsourcing company CrowdFlower (Kyriakidis et al., 2015). These surveys have, with the exception of the British poll, also detected signs of recognition that autonomous vehicles may bring road safety benefits but, in addition, all three surveys reported several concerns including possible system/equipment failure and hacking or misuse. However, there are two notable issues with surveys conducted to date: (i) they focus on autonomous road vehicles of the future without comparing opinions on existing transport, and (ii) they focus on opinion from the perspective of users of autonomous vehicles, overlooking the perspective of external road users, such as pedestrians.

Almost half of the people killed around the world each year in collisions are more vulnerable road users, i.e. motorcyclists, cyclists and pedestrians (WHO, 2016). However, research indicates that, while road users like pedestrians may be vulnerable to becoming victims of these incidents, their risky behaviours, just like drivers' risky behaviours, may also contribute to such outcomes (King et al., 2009). Moreover, research has suggested that gender and age differences in risky pedestrian behaviour could exist, albeit not always consistently (Holland and Hill, 2007; Rosenbloom, 2009; Rosenbloom and Wolf, 2002), and linked collisions to individual and personality differences in pedestrians such as sensation seeking (Schwebel et al., 2009). So even if autonomous cars were to behave more safely around pedestrians than human-operated cars, would car-pedestrian interactions actually be, and be perceived to be, less risky, given pedestrian behaviour also plays a role in the outcome of these interactions?

1.4 Aims of current study

The current study surveyed perceptions of autonomous cars, focusing particularly on the perceived risk of collision and injury for those travelling in them and those on foot, and on general attitudes towards these cars reflecting acceptance or objection to them being used on public roads. Given this focus, it was of particular interest to examine the perceptions of certain groups (i.e. males, younger adults) linked with poorer road safety – either as victims or as contributors through their risk-taking behaviours. Would these groups be more or less accepting of autonomous cars than other groups? Moreover, would different road users perceive autonomous cars to be more or less risky than other autonomous and human-operated vehicles already existing in our environment?

2. Materials and Methods

2.1 Participants

The research was advertised via online means of communication open to a variety of demographics (i.e. websites, social media, academic electronic notification systems) inviting the general public to take part in a short online survey about their perceptions of autonomous vehicles. The participant information mentioned that the survey would investigate pedestrian as well as passenger perspectives. Incentives were not offered for participation.

Data collection began in April 2016 and analysis took place in October 2016. In this time, 1048 surveys were completed; some were excluded due to the respondents either residing outside of the UK (93), indicating that they had already completed the survey before (25), or were under 18 years of age (5) and therefore not eligible for this study. Thus, the size of the sample was 925 participants. Of this sample, 64% were male and 35% female, with 1% (9 participants) preferring not to answer. Ages ranged from 18 to 85 years (M = 41.14, SD = 12.85, Mdn = 39.00) and 86% of the sample reported having a driving licence. Compared to the UK population, based on national statistics gathered in mid-2015 (49% male, 51% female, a median age of 40 years; Office for National

Statistics, 2016), this sample differs with respect to gender ratio ($X^2(1) = 90.69$, $p < .001$) but not age ($X^2(1) = 2.14$, $p = .143$). Direct comparisons between this sample and the UK population regarding licensed drivers is not possible due to geographical limitations in the statistical reporting. However, it may be useful as a general guide to report available statistics for Great Britain: based on licence (Department for Transport, 2016b) and population (Office for National Statistics, 2016) estimates, it is calculated that 78% of adults aged 18 to 85 years old in that part of the UK had a driving licence in mid-2015.

As males were over-represented and females under-represented here, compared to the UK population, the data was weighted using the gender proportions from the national statistics population estimates (Office for National Statistics, 2016). Following this weighting, participants were characterised as follows: Sample size = 916, excluding the nine non-responders to the gender question; Gender = 49% male, 51% female; Age range = 18 to 85 years, M = 40.91, SD = 12.93, Mdn = 39.00; 85% with a driving licence.

2.2 Materials

The online survey took, on average, less than 10 minutes to complete and consisted of two sections: "Background", which collected information on socio-demographics and risk-taking, and "Perception of Vehicles", which measured perceived risk and then general attitudes.

Road User Risk-Taking. The propensity for risky behaviours relating to various road user populations was measured using a six-item instrument. Participants were asked to rate their likelihood of engaging in the 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"). The scale, instructions, and three of the six items ("Driving a car without wearing a seat belt", "Walking home alone at night in an unsafe area of town" and "Riding a bicycle without wearing a helmet") were all taken from the Health/Safety subscale of the DOSPERT Risk-Taking Scale (Blais and Weber, 2006), although the latter item was modified slightly to refer to a bicycle rather than motorcycle. The remaining items ("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") were created for this study.

Perceived Risk. Participants were asked to rate the level of risk they associated with various modes of transport, from the point of view of different populations, i.e. (i) the driver/rider of a human-operated car, motorcycle and bicycle; (ii) a passenger of a train and car, both human-operated and autonomous; and (iii) a pedestrian in an area with cars, both human-operated and autonomous. Perceived risk for autonomous cars, when a passenger and when a pedestrian, was of key interest. Risk was defined as "the potential for an accident to occur, resulting in unwanted negative consequences to one's own life or health" and, with the exception of trains, participants were provided with the context of travelling in "heavy traffic". 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").

General Attitudes. Participants were asked to select one of six statements that best summed up their attitude towards the future use of autonomous vehicles on public roads (see Table 1). Alternatively, they could select "Other" and sum up their attitude using their own words.

Table 1. Six statements summing up general attitudes towards autonomous cars

Attitude	Definition	Statement
Positive	Explicit acceptance of autonomous cars	1. "We have nothing to fear"
Conditionally positive	Explicit acceptance although with a caveat	2. "I accept the concept but will always be concerned that something could go wrong"
Uncertain	No explicit acceptance or	3. "We need to know a lot more about the

	opposition but some concerns raised	intrinsic road safety capabilities of these vehicles”
		4. “My main concern is that these vehicles could be made unsafe through a computer virus or malicious hacking”
Conditionally Negative	Explicit opposition unless some condition is met	5. “I am opposed to these vehicles ever being allowed on public roads without complete manual override controls”
Negative	Explicit opposition of autonomous cars	6. “I am opposed to these vehicles ever being allowed on public roads”

2.3 Data analysis

Statistical analyses were conducted using the software package IBM SPSS Statistics version 22 and its Complex Samples module. The statistics presented in section 3 are the weighted results; unweighted results are shown in the Appendix for comparison purposes. Psychometric properties of the risk-taking instrument were assessed first using the methods described in section 3.1, and then the relationships between Risk-Taking and Gender and Age were investigated using the CSGLM procedure (an independent samples t-test and Pearson’s correlation test, respectively, were used with the unweighted data). Next, participants’ perceived risk ratings were examined across different population and vehicle types, again using the CSGLM procedure (participants in the repeated measures were treated as clusters and a Bonferroni correction was applied for multiple pairwise comparisons; for the unweighted data, Pearson’s correlation, repeated measures ANOVA with a Bonferroni correction, and paired samples t-test were used). Furthermore, the CSGLM procedure (ANCOVA for the unweighted data) was used to test the effect of Gender as a fixed factor and Age and Risk-Taking as covariates on each of these Perceived Risk variables. Lastly, as the assumption of proportional odds (“parallel lines”) was rejected when the data was examined, the CSLOGISTIC procedure (multinomial logistic for the unweighted data) rather than ordinal regression – with "Uncertain" as the reference category – was performed to test for significant relationships between Gender, Age, Road User Risk-Taking, Perceived Risk, Driver Status and attitudes towards autonomous cars.

3. Results

3.1 Road user risk-taking

The summed scores on the road user risk-taking instrument ranged from 6 to 40 (M = 19.62, SD = 6.61). Exceeding the speed limit and crossing the road when told not to were the risky behaviours participants were most likely to engage in (both Mdn = 5.00, $IQR_{speeding}$ = 2.00-6.00 and $IQR_{crossing}$ = 3.00-6.00) while driving without a seat belt was the least likely, with scores heavily positively skewed (Mdn = 1.00, IQR = 1.00-1.00).

To see whether the six items reflected a single risk-taking dimension, a principal axis factor analysis with the direct oblimin oblique rotation method was performed, with acceptable results (see Field, 2013): Determinant = .49, Overall KMO = .71, Individual KMO's all > .68, Bartlett's Test p < .001. It emerged that there was just one factor underlying the risk-taking instrument (eigenvalue > 1, explaining approximately 36% of the variance; a scree plot supported this result). However, it was noted that the item about driving without a seat belt did not load highly on this factor. Furthermore, when Cronbach's alpha was calculated to provide an estimate of the reliability of the risk-taking instrument, the removal of this seat belt item improved the alpha value. Thus it was removed and the road user risk-taking instrument now contained five items. The summed scores were then re-calculated; they ranged from 5 to 35 (M = 18.36, SD = 6.39). Cronbach's alpha was now .65. Further analysis revealed that the removal of any more items from the instrument would not increase alpha.

The summed scores on the risk-taking instrument were then analysed according to gender and age. As expected, males displayed a significantly greater propensity for road user risk-taking (M = 19.88, SD = 6.29) than did females (M = 16.91, SD = 6.14), t(915) = 6.93, p < .001, while younger participants had a significantly greater propensity for road user risk-taking than did older participants ($r = -.12$, $p < .001$).

3.2 Perceived risk for different population and vehicle types

Overall, as Table 2 shows, participants rated being the passenger of a train as least risky, with a mean risk rating approximating 2, i.e. “moderately low” risk. Being the rider of a bicycle was rated as most risky (approximating 5, “somewhat high” risk). Riding a motorcycle was also perceived as “somewhat high” risk. Autonomous cars, from the perspective of both a passenger in and a pedestrian around them, received mean risk ratings approximating 3, i.e. “somewhat low” risk. Qualitatively speaking, this placed autonomous cars on an equivalent lower level of risk to human-operated cars (from the perspective of a driver and passenger at least). From a quantitative perspective, in contrast, it looked as though the perceived riskiness of autonomous cars, compared to human-operated ones, might differ based on the population in question. Moreover, perceived risk ratings did appear to differ by gender, with females often giving higher ratings across population and vehicle types. Correlations also highlighted differences in perceived risk ratings according to participants’ age and their road user risk-taking propensities.

3.2.1 Driver/Rider of human-operated vehicle

First to be compared using inferential statistics was perceived risk for operating a car vs. motorcycle vs. bicycle. Risk ratings differed significantly across vehicle types, $F(2, 914) = 613.81$, $p < .001$; pairwise comparisons revealed that driving a car was perceived as significantly less risky than riding a motorcycle ($p < .001$) or bicycle ($p < .001$), and riding a bicycle was perceived as significantly more risky than riding a motorcycle ($p < .001$). Also, females and younger participants perceived operating a vehicle to be significantly more risky than did males and older participants, respectively, whether the vehicle was a car (Gender: $F(1, 915) = 7.05$, $p = .008$; Age: $F(1, 915) = 22.08$, $p < .001$), motorcycle (Gender: $F(1, 915) = 11.68$, $p = .001$; Age: $F(1, 915) = 7.18$, $p = .007$), or bicycle (Gender: $F(1, 915) = 17.96$, $p < .001$; Age: $F(1, 915) = 5.27$, $p = .022$). Ratings did not differ by risk-taking (Motorcycle: $F(1, 915) = 0.07$, $p = .792$; Bicycle: $F(1, 915) = 0.67$, $p = .414$) except for when the vehicle was a car: i.e. the greater the propensity for taking road user risks, the less risky operating a car was perceived to be ($F(1, 915) = 17.11$, $p < .001$).

Table 2. Perceived risk by Population and Vehicle type, Gender, Age and Risk-Taking

Population	**Vehicle**	**HOV vs. AV**	**All**	**Male**	**Female**	**Age**	**R-T**
Driver	Car	HOV	2.98 (1.54)	2.77 (1.44)	3.18 (1.60)	-.15***	-.14***
Rider	Motorcycle	HOV	4.97 (1.56)	4.77 (1.55)	5.15 (1.55)	-.10**	-.01
Rider	Bicycle	HOV	5.20 (1.54)	4.98 (1.55)	5.41 (1.50)	-.09**	.01
Passenger	Train	HOV	1.71 (1.10)	1.51 (0.86)	1.89 (1.26)	-.18***	-.17***
Passenger	Train	AV	1.72 (1.10)	1.47 (0.88)	1.95 (1.23)	-.16***	-.13***
Passenger	Car	HOV	2.90 (1.43)	2.73 (1.34)	3.06 (1.50)	-.08*	-.15***
Passenger	Car	AV	3.18 (1.61)	2.79 (1.49)	3.54 (1.63)	.01	-.01
Pedestrian	--	HOV	3.52 (1.57)	3.34 (1.50)	3.70 (1.62)	-.20***	-.10**

Pedestrian	--	AV	3.20 (1.61)	2.77 (1.47)	3.61 (1.63)	-.02	-.04

*Note: HOV = human-operated vehicle, AV = autonomous vehicle, All = Mean ratings (and SD) for all participants (N = 916), Male = Mean ratings (and SD) for males (n = 446), Female = Mean ratings (and SD) for females (n = 470), Age = correlation between Age and ratings; R-T = correlation between Risk-Taking summed scores and ratings; * = p < .05, ** = p < .01, *** = p < .001*

3.2.2 Passenger in human-operated vs. autonomous vehicle

Next, perceived risk was compared for being a passenger when in a human-operated vs. autonomous vehicle. Risk ratings did not differ when the vehicle was a train, $t(915) = 0.59$, $p = .554$. However, being a passenger in an autonomous car, as opposed to a human-operated car, was perceived as significantly more risky, $t(915) = 4.26$, $p < .001$. Being a passenger in an autonomous car was also perceived as significantly more risky than being a passenger in an autonomous train, $t(915) = 24.50$, $p < .001$.

Females always perceived being a passenger in a vehicle to be significantly more risky than did males, whether that vehicle was a human-operated train ($F(1, 915) = 13.21$, $p < .001$), an autonomous train ($F(1, 915) = 27.63$, $p < .001$), a human-operated car ($F(1, 915) = 4.99$, $p = .026$), or an autonomous car ($F(1, 915) = 49.81$, $p < .001$). Moreover, being a passenger was perceived to be significantly more risky when participants were younger or had a lower propensity for taking road user risks, as opposed to being older or more likely to take risks; this was the case when the vehicle was a human-operated train (Age: $F(1, 915) = 31.31$, $p < .001$; Risk-Taking: $F(1, 915) = 16.59$, $p < .001$), an autonomous train (Age: $F(1, 915) = 21.23$, $p < .001$; Risk-Taking: $F(1, 915) = 7.11$, $p = .008$), and a human-operated car (Age: $F(1, 915) = 8.29$, $p = .004$; Risk-Taking: $F(1, 915) = 17.14$, $p < .001$). However, when the vehicle was an autonomous car there were no significant differences according to age or risk-taking (Age: $F(1, 915) = 0.97$, $p = .326$; Risk-Taking: $F(1, 915) = 1.54$, $p = .215$).

3.2.3 Pedestrian in area with human-operated vs. autonomous cars

Following this, perceived risk was compared for being a pedestrian in an area with human-operated vs. autonomous traffic. This was perceived as significantly less risky when the traffic consisted of autonomous as opposed to human-operated cars, $t(915) = -4.53$, $p < .001$. Females again perceived significantly greater risk than did males, whether the surrounding traffic was human-operated cars ($F(1, 915) = 4.92$, $p = .027$) or autonomous cars ($F(1, 915) = 58.69$, $p < .001$). In addition, being a pedestrian around human-operated traffic was perceived to be significantly more risky when participants were younger or had a lower propensity for taking road user risks than when they were older or more likely to take risks (Age: $F(1, 915) = 39.91$, $p < .001$; Risk-Taking: $F(1, 915) = 10.19$, $p = .001$). However, there were no significant differences according to age or risk-taking when the traffic was autonomous cars (Age: $F(1, 915) = 0.00$, $p = .951$; Risk-Taking: $F(1, 915) = 0.22$, $p = .638$).

3.3 General attitude towards autonomous cars

When it came to summing up their attitudes towards the future use of autonomous vehicles on public roads, it was noticeable that, overall, few participants showed opposition (7% conditionally negative, 3% negative; see Table 3). Most often they were uncertain (24% choosing the statement expressing a need to know more about the cars' road safety capabilities). However, 19% were positive towards autonomous cars ("nothing to fear"). The same rounded percentage of participants were uncertain over computer viruses/hacking, while 18% were conditionally positive (accepting the cars but still with the concern that something could go wrong). Just over a tenth (95 participants) selected "Other", opting to sum up their attitudes using their own words.

Gender, Age and Risk-Taking were considered again. Some differences were evident (e.g. a higher percentage of males with a positive attitude, more uncertain females; a noticeably higher mean age for participants with a negative attitude), although not so obvious for risk-taking. Participants' risk ratings from the Perceived Risk question – only for autonomous cars, when a passenger and pedestrian – were also included here and there appeared to be a relationship (e.g. ratings were around 2 on average, i.e. "moderately low" risk, when a positive attitude, while risk ratings were at least twice that when a negative attitude). Given attitudes towards autonomous cars could be influenced by factors not only related to risk/safety but also e.g. a passion for driving, driver status was considered here too but responses between those with and without a driving licence ("Driver" and "Non-driver") looked mostly similar.

Table 3. Attitude (statements) by Gender, Age, Risk-Taking, Perceived Risk and Driver Status

	Positive	**Conditionally Positive**	**Uncertain**		**Conditionally Negative**	**Negative**	
	Nothing to fear	**Accept but concerned**	**Road safety capability**	**Virus or hacking**	**Opposed without override**	**Opposed**	**(Other)**
All %	19	18	24	19	7	3	10
Male %	28	19	19	16	4	2	13
Female %	11	17	29	22	9	3	8
Age M	39.01	42.18	42.62	38.93	40.30	50.68	40.00
(SD)	(11.99)	(12.31)	(13.10)	(13.53)	(14.55)	(10.71)	(12.04)
R-T M	19.09	18.73	17.34	18.06	17.75	19.14	19.46
(SD)	(6.25)	(6.29)	(6.06)	(6.15)	(7.50)	(7.37)	(6.79)
PR Pass.M	2.11	3.05	3.57	3.44	4.70	4.33	2.74

(SD)	(1.26)	(1.28)	(1.48)	(1.57)	(1.59)	(2.38)	(1.42)
PR Ped. M	2.06	3.16	3.59	3.38	4.63	4.78	2.86
(SD)	(1.29)	(1.26)	(1.45)	(1.62)	(1.48)	(2.15)	(1.45)
Driver %	19	19	24	18	6	3	10
Non-driver %	20	13	24	23	8	1	11

Note: M = Mean, SD = Standard Deviation; R-T = Risk-Taking; PR Pass. = Perceived risk rating for passenger in autonomous car; PR Ped. = Perceived risk rating for pedestrian around autonomous cars

Table 4. Attitude ("Other") by Gender, Age, Risk-Taking, Perceived Risk and Driver Status

	Positive	**Conditionally Positive**	**Uncertain**	**Conditionally Negative**	**Negative**	**(Missing)**
No. of participants	10	50	22	8	4	1
Male %	5	49	31	7	7	--
Female %	18	61	11	11	0	--
Age M	38.56	37.69	44.88	40.67	48.20	--
(SD)	(11.86)	(12.03)	(10.71)	(9.25)	(18.79)	
R-T M	19.83	19.14	19.14	18.94	24.00	--
(SD)	(6.85)	(6.71)	(7.45)	(5.76)	(7.20)	
PR Pass. M	1.50	2.69	3.37	2.74	3.40	--
(SD)	(0.77)	(1.30)	(1.50)	(1.45)	(2.04)	
PR Ped. M	1.57	2.81	3.51	2.74	3.60	--
(SD)	(0.52)	(1.40)	(1.51)	(1.65)	(0.93)	
Driver %	11	53	23	9	5	--
Non-driver %	7	57	29	7	0	--

Note: M = Mean, SD = Standard Deviation; R-T = Risk-Taking; PR Pass. = Perceived risk rating for passenger in autonomous car; PR Ped. = Perceived risk rating for pedestrian around autonomous cars

The "Other" answers, where attitudes were summed up in participants' own words, were then examined more closely. A detailed presentation of these answers is beyond this paper's scope. However, they too expressed various stances, for example:

- Positive:
  - "*I can't wait!*"
  - "*I am very excited by the potential of autonomous vehicles to improve the safety of our roads and the accessibility of travel for everyone*"
- Conditionally positive:
  - "*I welcome the advancements in technology, provided it has been independently and rigorously (scientifically!) tested/researched*"
  - "*Accept the concept, as long as standards are set for the behaviour of the vehicles (how to prioritise people/cars, etc.)*"
- Uncertain:
  - "*I do not know enough about their capabilities and safety features to make an informed decision*"
  - "*My main concern is other vehicles, cyclists or pedestrians. If, for example, they know that an autonomous vehicle will stop, will they simply pull out in front of them?*"
- Conditionally negative:

- "*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*"
- "*I am opposed to these vehicles … but … expect to be EDUCATED about all their capabilities (including road safety) before they are 'allowed loose' on our roads*"

- Negative:
  - "*I do not like being in a vehicle that I am not in control of because I do not trust others' instincts or experience*"
  - "*If my own computer is a guide, I would not trust any autonomous vehicle*"

Having been coded into the above five categories (inter-rater reliability: Cohen's kappa = .86), the "Other" answers were then examined across the same variables as before (see Table 4). The data for these freely-expressed attitudes broadly followed a similar pattern to that from participants who chose one of the attitude statements provided, although females selecting "Other" appeared to be more positive and less uncertain about autonomous vehicles than males and the mean risk-taking summed score for a negative attitude appeared relatively higher.

The coded "Other" answers were combined with the statements data (see Table 5) and entered into a regression model with Attitudes as the dependent variable and Gender, Age, Road User Risk-Taking, Perceived Risk and Driver Status as the independent variables (Model X^2 (24) = 143.88, $p < .001$; Nagelkerke $R^2 = .28$). In summary, the results showed that participants were:

- Significantly more likely to have a positive attitude towards autonomous cars if they were male (b = 0.61, SE = 0.22, p = .006, Odds Ratio = 1.84), younger (b = -0.02, SE = 0.01, p = .039, Odds Ratio = 0.98), or if they perceived autonomous cars as less risky, from the perspective of a passenger (b = -0.39, SE = 0.11, p < .001, Odds Ratio = 0.67) or pedestrian (b = -0.48, SE = 0.12, p < .001, Odds Ratio = 0.62);

- Significantly more likely to have a conditionally positive attitude if they perceived autonomous cars as less risky, from the perspective of a passenger (b = -0.24, SE = 0.09, p = .008, Odds Ratio = 0.79);
- Significantly more likely to have a negative attitude if they were older (b = 0.06, SE = 0.02, p < .001, Odds Ratio = 1.06) or if they perceived autonomous cars as more risky, from the perspective of a pedestrian (b = 0.74, SE = 0.21, p < .001, Odds Ratio = 2.09).

Driver Status was not a significant predictor of general attitudes towards autonomous cars (all ps > .244, all Odds Ratios < 1.20). Furthermore, unlike in the analysis of the unweighted data (see Appendix), participants who perceived autonomous cars as more risky, from the perspective of a passenger, were not significantly more likely to have a conditionally negative attitude (b = 0.27, SE = 0.16, p = .086, Odds Ratio = 1.31). Likewise, participants with a greater propensity for taking road user risks were not significantly more likely to have a negative attitude (b = 0.05, SE = 0.03, p = .108, Odds Ratio = 1.05) – again, in contrast to the results with the unweighted data. However, in all other respects, the analyses with unweighted and weighted data produced the same findings.

Table 5. Attitude (combined) by Gender, Age, Risk-Taking, Perceived Risk and Driver Status

	Positive	**Conditionally Positive**	**Uncertain**	**Conditionally Negative**	**Negative**	**(Missing)**
All %	20	23	46	7	3	1
Male %	28	25	39	4	3	--
Female %	13	22	52	10	3	--
Age M	38.98	41.13	41.18	40.35	50.33	--
(SD)	(11.95)	(12.37)	(13.29)	(13.97)	(11.69)	
R-T M	19.13	18.82	17.74	17.89	19.83	--

(SD)	(6.27)	(6.38)	(6.17)	(7.28)	(7.41)	
PR Pass. M	2.07	2.96	3.50	4.47	4.20	--
(SD)	(1.25)	(1.29)	(1.52)	(1.69)	(2.33)	
PR Ped. M	2.04	3.08	3.50	4.40	4.62	--
(SD)	(1.26)	(1.30)	(1.53)	(1.61)	(2.05)	
Driver %	20	24	45	7	3	--
Non-driver %	21	19	50	9	1	--

Note: M = Mean, SD = Standard Deviation; R-T = Risk-Taking; PR Pass. = Perceived risk rating for passenger in autonomous car; PR Ped. = Perceived risk rating for pedestrian around autonomous cars

4. Discussion

This study surveyed participants resident in the UK about their perceptions of autonomous cars, which are anticipated to improve road safety. Given males and younger adults are linked to poorer road safety, for reasons including their greater propensity for taking risks when operating vehicles or when pedestrians (Holland and Hill, 2007; Rosenbloom, 2009; Rosenbloom and Wolf, 2002; Turner and McClure, 2003), it was of particular interest to compare their perceptions – i.e. risk perception and general attitude towards autonomous cars – to those of other ages and gender. First, to ensure the sample was not “unusual” with regards to risk-taking, participants’ propensities for engaging in risky road user behaviours were tested for gender and age differences. Consistent with the research literature, participants who were male or younger were more likely to take such risks. To conduct these tests, an instrument in the style of the DOSPERT Risk-Taking Scale (Blais and Weber, 2006) was created, with items on risky behaviours by different types of road user population (i.e. driver/rider, passenger, pedestrian). Cronbach’s alpha was modest, however alpha represents the lower bound of the reliability and will be smaller when an instrument contains fewer items (Tavakol and Dennick, 2011) as this did given risk-taking was only one facet of the study. Factor analysis confirmed the instrument measured a single dimension but responses on one item, about not wearing a seat belt, stood out from the others: ratings were heavily skewed to the lower end of the scale and further analysis into the psychometric properties of the instrument led to the item being removed. The UK introduced seat belt usage laws for drivers, and other vehicle occupants, in the 1980s and early 1990s. Since this legislation – supported by law enforcement, public information campaigns, technology such as seat belt reminder systems, and reduced casualty rates – almost all UK drivers in passenger cars now reportedly wear seat belts (Road Safety Observatory, 2013). However, such legislation is not in place world-wide. This might explain in part why participant ratings for the seat belt item were almost universally low in the current study but why such risky behaviour is still considered a key factor to be tackled in global road safety (WHO, 2016).

Having established participants' risk-taking propensities, this study then examined their risk perceptions related to various vehicles, across different populations. Perceived risk ratings were first investigated from the point of view of a driver (or rider) of three human-operated vehicles: cars, motorcycles and bicycles, again providing an opportunity to check the sample was not idiosyncratic. The pattern of ratings did not quite match the objective relative risk of becoming a casualty when operating such vehicles, i.e. users are indeed at more risk on two wheels than four, but motorcyclists are more likely to be killed or seriously injured than bicyclists (Department for Transport, 2015b). However, while one study, in Norway, found that people could accurately perceive the relative risk of modes of transport (Elvik and Bjørnskau, 2005), a higher perceived risk for bicycling might not be "unusual" for people in the UK. On the contrary, the use of bicycles as a means of transport is lower in the UK compared to in many other countries (European Commission, 2013), and research has linked lower usage with higher perceived risk (Jacobsen et al., 2009). Moreover, perceptions are said to be influenced by factors such as the bicycling infrastructure (e.g. well-maintained continuous bicycle paths, separated from the roads and other road users) (Parkin et al., 2007); an issue where the UK is arguably found wanting while other Northern European countries lead the way. Although UK campaigners have called for improved safety provisions such as separate bicycle paths, some researchers have argued that this, ironically, increases the fear of bicycling as it highlights the dangers but, importantly, places the onus on bicyclists: i.e. *they* must be removed from other traffic (Jacobsen et al., 2009).

The current study then turned to its main focus: perceptions of autonomous cars. The idea that a vehicle could drive itself on the public roads did not seem to be perceived as risky in qualitative terms: in contrast to the objectively risky vehicles such as motorcycles and bicycles, which were subjectively rated on average in the "high" end of the risk scale, autonomous cars were rated equivalent to the objectively safer human-operated cars, i.e. in the "low" end of the risk scale. Also "low" risk were trains, both human-operated and autonomous. However, when looked at in quantitative terms, travelling in the cars of the future was imagined to be significantly riskier than travelling in existing autonomous trains. This difference may stem from autonomous rail systems such as the DLR being a known quantity while autonomous cars are yet to be seen and experienced. Such fear of the unknown may well have existed when autonomous trains were first mooted. Unfortunately, due to the lack of systematic collections of opinion about such autonomous trains at the time of their conception and arrival (and subsequently), it is unclear whether the current favourable perception of these existing rail systems grew as they become available to the public and their safety performance was demonstrated. If that was the case, however, then automotive and technology companies could possibly convince the public by engaging them in accessible and transparent demonstrations of autonomous cars and their safety.

Staying with quantitative comparisons, autonomous trains were perceived in this study as no more risky than their human-operated counterparts, whereas autonomous cars fared less well in such a comparison. However, this was when participants were responding from the perspective of a passenger. When responding as a pedestrian, autonomous cars were perceived to be significantly less risky than their human-operated counterparts. These results suggest that risk perceptions might have been shaped more here by issues concerning road interactions, thus highlighting the need to consider the public not as a single entity when canvassing opinion but as various road users; people may hold multiple points of view about autonomous cars depending on the nature of their potential interactions with them.

The passenger versus pedestrian differences were possibly influenced by issues concerning whose safety autonomous cars might opt to prioritise in the event of a potential collision. Research from the USA (Bonnefon et al., 2016) revealed participants would rather that an autonomous vehicle was programmed to prioritise the safety of pedestrians, if they outnumbered the vehicle's passengers. This remained the case even when those passengers were imagined to be the participants themselves plus a loved one. However, while such vehicular behaviour was seen as more moral, it was also revealed as less enticing, with participants less likely to buy a vehicle programmed to minimise casualties, that is, potentially prioritise external road users over them. In the current study, the caveats and concerns expressed in the "Other" attitude answers showed ethics and vehicular behaviour were certainly an issue for some of the sample. As one participant opined, "*Right now, it's a natural reaction and in an accident you try not to kill yourself but if a computer has to make the decision it will do what it's programmed to do*". Thus, if believing that a human driver would act more out of a survival instinct than utilitarianism, one's chances of surviving a collision might seem greater when travelling in a human-operated as opposed to autonomous car.

The ethical issue is a perplexing one. If decisions made by autonomous cars are based on the number of potential casualties, would people reject autonomous cars, instead opting to travel in larger passenger vehicles to increase the likelihood that the balance of whose survival to prioritise would be in their favour? Also, how would an autonomous car tell how many casualties could be saved in an impending collision with a larger passenger vehicle – while UK buses can carry up to 70+ passengers, they do not always run at full capacity. Therefore, the number of car occupants could outweigh bus occupants at times. Additionally, decisions based on casualty numbers could further discourage lone road users such as bicyclists and also unaccompanied pedestrians; this would not only work against government aims to create a "walking and cycling nation" (Department for Transport, 2016c) but also be ironic given bicyclists and pedestrians would be sharing the roads with theoretically safer "drivers" and therefore be less vulnerable. Moreover, this could undo the current more favourable perception of autonomous cars demonstrated by pedestrians here.

However, the above problems may be academic. First, no autonomous car manufacturer has actually stated to date that their vehicles will be programmed to behave in a utilitarian way. One senior manager who did speak out seemed to suggest that their cars would in fact prioritise passengers, although the company has since claimed the person was misquoted and that "*neither programmers nor automated systems are entitled to weigh the value of human lives*", appearing to place the decision on whose safety to prioritise with lawmakers (Morris, 2016). It is worth noting though that Bonnefon et al. (2016) found public opposition to legal enforcement of vehicular behaviour, at least if utilitarian. Second, this discussion overshadows a key point: the logic at the core of autonomous cars is they are being designed to avoid possible collisions in the first place. If successful, then questions about the how the vehicles will behave in such (rare) events could seem less pertinent.

Gender differences pervaded the current study: compared to females, males were more likely to perceive autonomous cars (and autonomous trains and various other human-operated vehicles) as less risky and have a positive attitude towards autonomous cars, demonstrating acceptance. This is consistent with the earlier survey findings of Schoettle and Sivak (2014). Gender differences in risk perception have been found in a number of contexts but, to date, theories posited as explaining these differences fail to wholly convince. For instance, Kahan et al. (2007) reject earlier suggestions that females tend to perceive greater risk than males because they are biologically or socially disposed to a carer role and are therefore more sensitive to risk; instead, they argue that gender differences arise from perceived threats to cultural identities. In other words, individuals are motivated to minimise the perception of risk if that risk is associated with, and therefore threatens, an activity or position to which they relate; conversely, they will seek to heighten the perceived risk if it aligns with their cultural norms. So, Kahan et al. argue, persons who orient towards hierarchies or individualism and thus put their own group's needs above others' or are competitive – according to the authors, and dependent on the context, these may more often be males – will give lower risk ratings to something if that helps defend their cultural identity. In contrast, persons who orient towards egalitarianism or communitarianism will give higher risk ratings to something if it threatens their identity by promoting social inequalities and marginalising or isolating people. Viewed in the context of autonomous vehicles, it could be argued that those vehicles, the efforts surrounding their creation, and certain public figures seen to spearhead such efforts, are associated with independence, competition and enterprise – characteristics that may be perceived as being more typically male, and thus this might explain males rating autonomous vehicles as being less risky. However, one of the expected benefits of autonomous vehicles, in addition to improved road safety, is increased mobility for all, including those who might currently be socially isolated (e.g. older adults, those with health issues) – something that conforms with the egalitarian/communitarian worldview. There is no obvious reason why females should align more with such a worldview in this context than males, and so, following the theory, the risk ratings of both genders should not have differed yet this was not the case. Thus, cultural identity threats would not appear to provide a satisfactory explanation for the gender differences observed here.

Schoettle and Sivak's survey (2014) also found that younger participants were less likely to be against travelling in an autonomous vehicle, a result replicated here: age differences affected the more extreme attitudes with younger participants more often accepting autonomous cars and less often outright opposing them than older participants. Younger participants also perceived vehicles of different types to be more risky than did older participants, a finding that might perhaps be due to the former group having relatively fewer years of experience in and around transport and/or being aware of their greater objective risk of becoming a fatal collision casualty. However, age differences were not detected when the vehicle was an autonomous car, which supports both explanations given neither group are likely to have seen or tried these vehicles yet and it is too early to compile collision statistics for them.

That male and younger adults are more accepting of autonomous cars would at first glance appear to be an encouraging result since these populations are more likely to take road user risks, which contribute to poorer road safety. So, if such populations were to embrace using autonomous cars, then the anticipated road safety benefits should manifest quickly. Yet, an initial result from the unweighted data suggested caution: participants who were more likely to take road user risks were also more likely to have a negative attitude towards autonomous cars, raising the question that, if given the choice, might risk-takers reject using these vehicles? However, when the data was weighted to enhance the sample's representativeness of the UK population, this result was no longer statistically significant. Despite that, risk is an attractive element for groups more prone to risky driving and pedestrian behaviour (e.g. sensation seekers; Schwebel et al., 2009; Zimbardo et al., 1997). Thus, it seems logical to consider further whether autonomous cars' major selling point, safer driving, might prove to reduce their appeal to the very individuals whose use of them would most benefit other road users. One could argue that, if risk-takers view risk more positively, then their perceived risk ratings in the current study should have been higher for risky vehicles, which was not the case. However, the seemingly contradictory results might derive from a conflation of risk as a "positive" and "negative" by risk-takers. For example, where the opportunity for thrills may be outweighed by the high chance of becoming a collision casualty (i.e. two-wheeled vehicles), risk-takers responded similar to other participants. However, where the chance of harm was objectively lower, risk-takers may have had a keener perception for opportunities for risk-taking; so trains were perceived as less risky as risk-takers rightly noted the little opportunity for passenger behaviour to affect the vehicle, whereas human-operated cars were perceived as less risky because while they afford greater opportunity for risk-taking, this is viewed as appealing, not a negative risk. Risk-takers' ratings of autonomous cars may not have differed from others' ratings because while these vehicles are being promoted as safer, the risk and opportunities for thrills are not yet known. It would seem worthwhile revisiting the issue of risk-taking and user acceptance once people with this propensity have a chance to see and interact with autonomous vehicles on the public roads.

While other risk-related variables had significant relationships with attitudes towards autonomous cars, gender and age differences were still detected when holding these variables constant. Thus, attitudes were clearly affected by more than just differences surrounding risk. Previous research has reported that males will make decisions based on selective information and younger adults are better at processing new, complex information whereas, in contrast, females seek more details before making decisions and are less willing to attempt to overcome things that appear tricky while older adults are less capable of doing so (Venkatesh et al., 2012). Thus, autonomous cars would be more appealing to males and younger participants than females and older participants given it is relatively novel, certainly complex technology with benefits clearly promoted but a number of significant challenges yet to be solved (see, for example, Anderson et al., 2016).

Perhaps surprisingly, driver status was not a factor that significantly affected attitudes. Although a passion for driving, being in control and concerns about deskilling were expressed in the "Other" answers, this was rare. More commonly, participants expressed concerns about human-operated vehicles sharing the roads with autonomous cars. In other words, they believed driverless cars would be safer, but worried that other, human road users would behave in a less-than-safe way around them. This further underlines the need to consider the public from the point of view of different road users and due consideration must be given to integrating the new technology with these different populations, not just in the short term but also longer term (e.g. will driver/rider, passenger and pedestrian behaviour towards autonomous cars change in a positive and/or negative way over time as the numbers of these vehicles on the roads increase and the cars' behaviours become more predictable? See Millard-Ball, 2016 who, using game theory, predicts that pedestrians at least may well exploit the predictable nature of autonomous vehicles, resulting in consequences for urban planning and policy).

When looking at the attitudes, either from the sample overall or across variables such as Gender and Driver Status, one thing was clear: participants who opposed autonomous cars were very much in the minority; 10% or less had a negative or conditionally negative attitude. Around four to five times more participants expressed acceptance of autonomous cars (e.g. 43% of the overall sample, 53% of males, and 44% of drivers respectively had a positive or conditionally positive attitude). This could be taken as an endorsement for autonomous cars. However, it should also be noted that there was a sizeable number of participants (46% of the overall sample and between approximately two-fifths and a half of subgroups) yet to be convinced. Often their concerns centred on the cars' road safety capabilities but concerns related to cybercrime, e.g. computer viruses and hacking, were also frequently expressed, underlining that this is not simply a challenge of improving transportation (i.e. travelling from A to B with the risks minimised) but improving systems more widely (e.g. running software applications with risks minimised). So these findings indicate that many people are currently receptive to the concept of autonomous cars but there is still work to be done.

5. Conclusions

This survey of perceptions revealed that autonomous cars were currently perceived in a generally positive light, overall: in terms of qualitative risk perceptions they were rated relatively well compared to existing modes of transport, and in terms of attitudes towards them there was little opposition displayed. Thus it would appear that the idea of autonomous cars on public roads has already found acceptance amongst many people. However, further findings highlight that much effort is still required to encourage widespread acceptance. Despite the low negativity evident, concerns were expressed, encompassing more than just road safety-related issues. Moreover, the detection of significant relationships between perceived risk ratings or attitudes and various factors, including road user populations, gender and age, emphasise that perceptions towards autonomous cars are multi-faceted. It will not be a case of technology and automotive companies having to win over "the public" per se as this study clearly demonstrates that the public is not a single entity with respect to this new revolutionary form of transport. For passengers, an autonomous car is perceived as riskier than a human-operated car, while for pedestrians an autonomous car is perceived as less risky than a human-operated car. As members of the public will likely be both types of road user, and the safety of both is imperative, this raises significant questions over the design and promotion of autonomous cars: companies will have to find ways to appeal to the former road user group while continuing to appeal to the latter to achieve a satisfactory integration of these vehicles in urban environments. A multi-perspective approach must also be adopted by researchers in future surveys as well as trials involving real interactions between people and these vehicles. Furthermore, while actual demonstrations of autonomous cars and their safety performance would be welcomed and likely quell some concerns, companies and researchers should continue to explore whether the vehicles' safety might prove to be unattractive to risk-takers – the group whose use of autonomous vehicles would be highly beneficial to society, given their link to poorer road safety; further thought may be required to create ways of encouraging adoption of the technology amongst such individuals.

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Appendix: Unweighted results – subject of analysis and accompanying descriptive and inferential statistics

Road user risk-taking

Summed scores (6-item instrument):

Range = 6 to 40, M = 20.12, SD = 6.63

Speeding item:

Mdn = 5.00, IQR = 3.00-6.00

Crossing item:

Mdn = 5.00, IQR = 3.00-6.00

Seatbelt item:

Mdn = 1.00, IQR = 1.00-1.00

Principal Axis Factor Analysis:

Determinant = .48, Overall KMO = .71, Individual KMO’s all > .67, Bartlett’s Test p < .001. One underlying factor (eigenvalue > 1, approx. 37% of variance explained).

Summed scores (5-item instrument):

Range = 5 to 35, M = 18.86, SD = 6.38

Cronbach’s α (seatbelt item removed) = .65

Gender difference for Risk-Taking:

Male: M = 19.88, SD = 6.29; Female: M = 16.91, SD = 6.14; t(914) = 6.87, p < .001, d = 0.48

Correlation between Age and Risk-Taking:

r = -.11, p < .001

Perceived risk for different population and vehicle types

Driver of HOV car:

All: M = 2.92, SD = 1.51; Male: M = 2.77, SD = 1.44; Female: M = 3.18, SD = 1.60; Age: r = -.14***; Risk-Taking: -.14***

Rider of HOV motorcycle:

All: M = 4.91, SD = 1.56; Male: M = 4.77, SD = 1.55; Female: M = 5.15, SD = 1.55; Age: r = -.12***; Risk-Taking: -.01

Rider of HOV bicycle:

All: M = 5.13, SD = 1.54; Male: M = 4.98, SD = 1.55; Female: M = 5.41, SD = 1.50; Age: -.10**; Risk-

Taking: -.00

Passenger of HOV train:

All: M = 1.65, SD = 1.04; Male: M = 1.51, SD = 0.86; Female: M = 1.89, SD = 1.26; Age: r = -.18***; Risk-Taking: -.16***

Passenger of AV train:

All: M = 1.65, SD = 1.05; Male: M = 1.47, SD = 0.88; Female: M = 1.95, SD = 1.23; Age: r = -.15***; Risk-Taking: -.12***

Passenger of HOV car:

All: M = 2..85, SD = 1.41; Male: M = 2.73, SD = 1.34; Female: M = 3.06, SD = 1.50; Age: r = -.08*; Risk-Taking: -.15***

Passenger of AV car:

All: M = 3.06, SD = 1.58; Male: M = 2.79, SD = 1.49; Female: M = 3.54, SD = 1.63; Age: r = .04; Risk-Taking: -.01

Pedestrian around HOV cars:

All: M = 3.47, SD = 1.55; Male: M = 3.34, SD = 1.50; Female: M = 3.70, SD = 1.62; Age: r = -.20***; Risk-Taking: -.10**

Pedestrian around AV cars:

All: M = 3.07, SD = 1.57; Male: M = 2.77, SD = 1.47; Female: M = 3.61, SD = 1.63; Age: r = .01; Risk-Taking: -.04

Perceived risk for driver/rider of HOV

Overall differences across vehicle types:

F(2, 1848) = 1117.31, p < .001, η_p^2 = .55;

Pairwise comparisons: car vs. motorcycle = p < .001; car vs. bicycle = p < .001; bicycle vs. motorcycle = p < .001

Gender , Age and Risk-Taking differences across vehicle types:

Car:

Gender: F(1, 912) = 7.60, p = .006, η_p^2 = .01; Age: F(1,

Appendix: Unweighted results – subject of analysis and accompanying descriptive and inferential statistics

912) = 21.59, $p < .001$, $\eta_p^2 = .02$); Risk-Taking: $F(1, 912) = 18.32$, $p < .001$, $\eta_p^2 = .02$

Motorcycle:

Gender: $F(1, 912) = 10.40$, $p = .001$, $\eta_p^2 = .01$; Age: $F(1, 912) = 11.93$, $p < .001$, $\eta_p^2 = .01$; Risk-Taking: $F(1, 912) = 0.00$, $p = .984$, $\eta_p^2 = .00$

Bicycle:

Gender: $F(1, 912) = 15.40$, $p < .001$, $\eta_p^2 = .02$; Age: $F(1, 912) = 8.46$, $p = .004$, $\eta_p^2 = .01$); Risk-Taking: $F(1, 912) = 0.17$, $p = .684$, $\eta_p^2 = .00$

Perceived risk for passenger of HOV vs. AV

Overall differences across vehicle types:

AV vs. HOV train: $t(924) = 0.00$, $p = 1.000$, $d = 0.00$;

AV vs. HOV car: $t(924) = 3.47$, $p < .001$, $d = 0.15$;

AV car vs. train: $t(924) = 26.56$, $p < .001$, $d = 1.34$

Gender , Age and Risk-Taking differences across vehicle types:

HOV train:

Gender: $F(1, 912) = 16.58$, $p < .001$, $\eta_p^2 = .02$;

Age: $F(1, 912) = 33.02$, $p < .001$, $\eta_p^2 = .04$;

Risk-Taking: $F(1, 912) = 25.10$, $p < .001$, $\eta_p^2 = .03$

AV train:

Gender: $F(1, 912) = 33.02$, $p < .001$, $\eta_p^2 = .04$;

Age: $F(1, 912) = 20.17$, $p < .001$, $\eta_p^2 = .02$;

Risk-Taking: $F(1, 912) = 9.92$, $p = .002$, $\eta_p^2 = .01$

HOV car:

Gender: $F(1, 912) = 5.45$, $p = .020$, $\eta_p^2 = .01$;

Age: $F(1, 912) = 7.94$, $p = .005$, $\eta_p^2 = .01$;

Risk-Taking: $F(1, 912) = 17.73$, $p < .001$, $\eta_p^2 = .02$

AV car:

Gender: $F(1, 912) = 52.27$, $p < .001$, $\eta_p^2 = .05$;

Age: $F(1, 912) = 3.30$, $p = .070$, $\eta_p^2 = .00$;

Risk-Taking: $F(1, 912) = 2.39$, $p = .122$, $\eta_p^2 = .00$

Perceived risk for pedestrian in area with HOV vs. AV cars

Overall differences across vehicle types:

AV vs. HOV cars: $t(924) = -6.10$, $p < .001$, $d = -0.26$

Gender , Age and Risk-Taking differences across vehicle types:

HOV cars:

Gender: $F(1, 912) = 5.23$, $p = .022$, $\eta_p^2 = .01$;

Age: $F(1, 912) = 39.54$, $p < .001$, $\eta_p^2 = .04$;

Risk-Taking: $F(1, 912) = 11.24$, $p < .001$, $\eta_p^2 = .01$

AV cars:

Gender: $F(1, 912) = 61.58$, $p < .001$, $\eta_p^2 = .06$;

Age: $F(1, 912) = 0.52$, $p = .470$, $\eta_p^2 = .00$;

Risk-Taking: $F(1, 912) = 0.41$, $p = .520$, $\eta_p^2 = .00$

Attitude (statements) towards autonomous cars

Positive/Nothing to fear:

All: 22%; Male: 28%, Female: 11%;

Age: $M = 38.66$, $SD = 11.69$;

Risk-Taking: $M = 19.43$, $SD = 6.15$;

Perceived Risk (Passenger): $M = 2.08$, $SD = 1.20$;

Perceived Risk (Pedestrian): $M = 2.02$, $SD = 1.22$;

Driver: 22%, Non-Driver: 23%

Conditionally positive/Accept but concerned:

All: 18%; Male: 19%, Female: 17%

Age: $M = 42.12$, $SD = 12.27$;

Risk-Taking: $M = 19.29$, $SD = 6.14$;

Perceived Risk (Passenger): $M = 3.01$, $SD = 1.31$;

Perceived Risk (Pedestrian): $M = 3.11$, $SD = 1.27$;

Driver: 19%, Non-Driver: 22%

Appendix: Unweighted results – subject of analysis and accompanying descriptive and inferential statistics

Uncertain/Road safety capability:

All: 22%; Male: 19%, Female: 29%

Age: M = 43.18, SD = 12.97;

Risk-Taking: M = 17.77, SD = 6.05;

Perceived Risk (Passenger): M = 3.47, SD = 1.46;

Perceived Risk (Pedestrian): M = 3.50, SD = 1.43;

Driver: 23%, Non-Driver: 21%

Uncertain/Virus or hacking:

All: 18%; Male: 16%, Female: 22%

Age: M = 39.36, SD = 13.46;

Risk-Taking: M = 18.36, SD = 6.32;

Perceived Risk (Passenger): M = 3.26, SD = 1.54;

Perceived Risk (Pedestrian): M = 3.20, SD = 1.57;

Driver: 17%, Non-Driver: 26%

Conditionally negative/Opposed without override:

All: 6%; Male: 4%, Female: 9%

Age: M = 41.14, SD = 14.81;

Risk-Taking: M = 18.00, SD = 7.61;

Perceived Risk (Passenger): M = 4.67, SD = 1.62;

Perceived Risk (Pedestrian): M = 4.51, SD = 1.46;

Driver: 5%, Non-Driver: 6%

Negative/Opposed:

All: 2%; Male: 3%; Female: 2%

Age: M = 50.83, SD = 10.82;

Risk-Taking: M = 20.26, SD = 7.54;

Perceived Risk (Passenger): M = 4.52, SD = 2.35;

Perceived Risk (Pedestrian): M = 5.00, SD = 2.05;

Driver: 3%, Non-Driver: 1%

Other:

All: 11%; Male: 12%; Female: 8%

Age: M = 41.02, SD = 12.51;

Risk-Taking: M = 20.12, SD = 6.75;

Perceived Risk (Passenger): M = 2.74, SD = 1.39;

Perceived Risk (Pedestrian): M = 2.82, SD = 1.45;

Driver: 11%, Non-Driver: 11%

Inter-rater reliability

Cohen's Kappa = .87

Attitude ("Other") towards autonomous cars

Positive:

No. of participants: 9

Male: 5%, Female: 19%;

Age: M =40.33, SD =13.67;

Risk-Taking: M = 21.00, SD = 6.65;

Perceived Risk (Passenger): M = 1.44, SD = 0.73;

Perceived Risk (Pedestrian): M = 1.56, SD = 0.53;

Driver: 9%, Non-Driver: 7%

Conditionally positive:

No. of participants: 54

Male: 49%, Female: 59%

Age: M = 38.65, SD = 12.20;

Risk-Taking: M = 19.48, SD = 6.59;

Perceived Risk (Passenger): M = 2.61, SD = 1.28;

Perceived Risk (Pedestrian): M = 2.61, SD = 1.41;

Driver: 52%, Non-Driver: 50%

Uncertain:

No. of participants: 28

Male: 32%, Female: 11%

Age: M = 44.96, SD = 11.71;

Risk-Taking: M = 20.25, SD = 7.30;

Perceived Risk (Passenger): M = 3.25, SD = 1.38;

Perceived Risk (Pedestrian): M = 3.46, SD = 1.43;

Appendix: Unweighted results – subject of analysis and accompanying descriptive and inferential statistics

Driver: 26%, Non-Driver: 36%

Conditionally negative:

No. of participants: 8

Male: 7%, Female: 11%

Age: M = 41.38, SD = 9.72;

Risk-Taking: M = 19.63, SD = 6.41;

Perceived Risk (Passenger): M = 3.00, SD = 1.51;

Perceived Risk (Pedestrian): M = 3.00, SD = 1.77;

Driver: 8%, Non-Driver: 7%

Negative:

No. of participants: 5

Male: 7%; Female: 0%

Age: M = 48.20, SD = 17.99;

Risk-Taking: M = 24.00, SD = 6.89;

Perceived Risk (Passenger): M = 3.40, SD = 1.95;

Perceived Risk (Pedestrian): M = 3.60, SD = 0.89;

Driver: 6%, Non-Driver: 0%

Missing:

No. of participants: 1

Attitude (combined) towards autonomous cars

Positive:

All: 23%; Male: 28%, Female: 13%;

Age: M =38.73, SD =11.74;

Risk-Taking: M = 19.49, SD = 6.16;

Perceived Risk (Passenger): M = 2.06, SD = 1.19;

Perceived Risk (Pedestrian): M = 2.00, SD = 1.20;

Driver: 23%, Non-Driver: 24%

Conditionally positive:

All: 24%; Male: 25%, Female: 22%

Age: M = 41.28, SD = 12.32;

Risk-Taking: M = 19.34, SD = 6.24;

Perceived Risk (Passenger): M = 2.91, SD = 1.31;

Perceived Risk (Pedestrian): M = 2.99, SD = 1.32;

Driver: 25%, Non-Driver: 18%

Uncertain:

All: 44%; Male: 39%, Female: 52%

Age: M = 41.70, SD = 13.23;

Risk-Taking: M = 18.19, SD = 6.27;

Perceived Risk (Passenger): M = 3.37, SD = 1.49;

Perceived Risk (Pedestrian): M = 3.37, SD = 1.49;

Driver: 43%, Non-Driver: 50%

Conditionally negative:

All: 6%; Male: 4%, Female: 10%

Age: M = 41.17, SD = 14.16;

Risk-Taking: M = 18.22, SD = 7.43;

Perceived Risk (Passenger): M = 4.44, SD = 1.69;

Perceived Risk (Pedestrian): M = 4.31, SD = 1.58;

Driver: 6%, Non-Driver: 7%

Negative:

All: 3%; Male: 3%; Female: 2%

Age: M = 50.36, SD = 12.01;

Risk-Taking: M = 20.93, SD = 7.45;

Perceived Risk (Passenger): M = 4.32, SD = 2.29;

Perceived Risk (Pedestrian): M = 4.75, SD = 1.96;

Driver: 3%, Non-Driver: 1%

Missing:

All: 1%

Regression test for (combined) attitudes

Model:

X^2 (24) = 283.38, p < .001; Nagelkerke R^2 = .29

Predictors of a positive attitude:

Appendix: Unweighted results – subject of analysis and accompanying descriptive and inferential statistics

Gender (Male): $b = 0.62$, $SE = 0.22$, $p = .006$, Odds Ratio = 1.85; Age: $b = -0.02$, $SE = 0.01$, $p = .004$, Odds Ratio = 0.98; Perceived Risk (Passenger): $b = -0.36$, $SE = 0.11$, $p < .001$, Odds Ratio = 0.70; Perceived Risk (Pedestrian): $b = -0.50$, $SE = 0.11$, $p < .001$, Odds Ratio = 0.60
Predictors of a conditionally positive attitude: Perceived Risk (Passenger): $b = -0.20$, $SE = 0.09$, $p = .021$, Odds Ratio = 0.82
Predictors of a conditionally negative attitude: Perceived Risk (Passenger): $b = 0.34$, $SE = 0.15$, $p = .021$, Odds Ratio = 1.41
Predictors of a negative attitude: Age: $b = 0.05$, $SE = 0.02$, $p = .002$, Odds Ratio = 1.05; Risk-Taking: $b = 0.07$, $SE = 0.03$, $p = .043$, Odds Ratio = 1.07; Perceived Risk (Pedestrian): $b = 0.82$, $SE = 0.21$, $p < .001$, Odds Ratio = 2.26
Not a significant predictor of attitudes: Driver Status: all ps > .090, all Odds Ratios < 1.01