Who Has The Right of Way, Autonomous Vehicles or Drivers? Multiple Perspectives in Safety, Negotiation and Trust

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ABSTRACT

Public opinion suggests that it is still unclear how people will react when autonomous vehicles (AVs) emerge on the roads. Fatal accidents involving AVs have received wide media attention, possibly disproportionate to their frequency. How does the framing of such stories affect public perceptions of AVs? Few drivers have encountered AVs, but how do they imagine themselves interacting with AVs in the near future when they are on the road? This survey study with 600 UK and Hong Kong drivers addressed these two questions. After reading news 'vignettes' reporting an imagined fatal accident, respondents presented with subjective information perceived AVs as less safe than those presented with factual information. We draw implications for news media framing effects and the attempts by AV promoters to counter negative newsflow with factual information. Respondents were also presented with an imagined interaction with human driven vehicles and AVs and did not differentiate between the two. Results from other variables e.g., first and third person framings, and cultural differences, are also reported.

KEYWORDS

Autonomous Vehicle, Trust, Negotiation, Safety

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1 INTRODUCTION

Autonomous vehicles (AVs), vehicles that can drive themselves without any human control or intervention, became a hot topic in recent years. This is because the advanced technology can potentially improve many aspects of traffic, in particular road safety. In 2018, 1.35 million traffic deaths were recorded worldwide [24] and NHTSA [22] reported that more than 90% of these traffic accidents in the U.S. were caused by human errors. Developers are confident that AVs, with sensors that monitor the surrounding environments in 360 degrees and processors that analyse more data [39], will be more reliable. However, despite this promise, safety is still a concern for people across different countries. Participants from across 40 countries in Kyriakidis, Happee and de Winter's study [15] in general expressed significant concern regarding safety towards AVs. Safety is a recurrent concern in other surveys [4] although a few suggest this concern is reducing (e.g. [6, 10]). More specifically, with the several high profile accidents recently including Uber's AV which killed a pedestrian [27] being reported in the news, how the presentation of such news affect people's perception of AV safety becomes important. This study therefore aims to draw deeper understanding into the subjectivity of information written in news reports and how this influences people's perceived safety towards AVs.

Safety perceptions will influence levels of trust in AVs, which will in turn affect people's interaction with AVs. How people interact with AVs in real-life is unclear because in reality few people have encountered them. One interaction we should pay attention to is how drivers interaction with AVs on the road. A minor accident involving a Google's AV in early 2016 in the U.S. highlights the need to understand this specific interaction. It was trying to leave its parking space only to find itself bumping into a bus because it assumed that the bus driver would give way to it [8]. Few studies have attempted to understand such interactions and how people might share and negotiate spaces with an AV, but this will matter since, for a considerable time, AVs will in reality be interacting with mostly human drivers. Thus, we believe that understanding how drivers interact with AVs in imaginary situations may help us predict what these interactions may look like in the future and facilitate smoother road-sharing interactions.

2 RELATED WORK

Perceived Safety in Subjective and Factual Information

While many studies addressed the fact that people across different countries expressed concern towards the safety of AV,

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the question of how people's responses are related to their cognitive processes of safety and trust received little attention. Hosanagar and Cronk [13] suggested that though cases where human trust algorithms were found such as evidence of human buying recommended items on an online shopping website Amazon [18], people's trust in algorithms seemed to be selective. They argued using Logg's study [20] that people were more likely to trust human's advice if decisions were subjective e.g., related to instincts or emotions, but were more likely to trust an algorithm's advice if decisions were objective e.g., related to logical reasoning. Moreover, not only did human unintentionally and selectively choose to trust algorithms, Dietvorst et al. [7] further showed that people lost trust in an algorithm much quicker than in a human forecaster when making the same mistake. Also, after all, participants were more likely to prefer advice from the human than the algorithm even when the algorithm performed better overall. Therefore, it is possible that algorithms are inherently prone to a larger variance in people's trust than human. If this theory is applied to AVs, people may also find AVs more unforgiving in making the same mistake such as a car crash than human. However, what if the algorithm is no longer compared with humans, but with itself that is described and reported differently, will its mistake still generate the same level of trust and safety in people?

With reference to the dual-processing model, it was suggested that situations that were personal and specific triggers affective and non-logical reasoning (system 1) and that impersonal and abstract situations triggered conscious and logical processing (system 2) [14, 32]. Therefore, depend on the type of information and the system that it triggers, the generated perception on the safety of AVs may be different. Hence, this study attempts to investigate whether different types of information presented (i.e. subjective or factual) in a news report about a car crash between an AV and a pedestrian may result in different levels of safety concern about AV, with subjective information being descriptions of the victim and detailed report of the car crash and factual information being descriptions of AVs' advanced equipment and hypothetical numerical figures of reduced accidents and fatalities since the implementation of AVs. With different reasoning systems being triggered, it is expected that AVs will be perceived as less safe in the condition that focuses on reporting the victim than in the condition that focuses on reporting statistical data.

Drivers' Interactions with AV

AVs versus Traditional Vehicles. Many studies that investigated in public's general perception on AVs clearly shows that people's attitudes towards AV are different from that towards traditional vehicles. For example people are significantly concerned about AVs' safety, privacy and related legal issues [15] which they wouldn't have otherwise if it was a manual driving vehicle (MV). People also prefer having at least partial control over the vehicle than complete automation [31], showing that they do not have the same level of acceptance to AVs than MVs or semi-AVs. However, investigating in these perceptions on a lower level of relevance to real-life scenarios makes it hard to infer how people might react to them in real-life. After all, it is people's real-life interaction with AVs that matters on a practical level.

When people are interacting with MVs, Tennant et al. [37] found that most drivers agreed that there are unwritten rules on the road that drivers expect other drivers to understand, i.e., how to behave towards each other. However, the question is, what if AVs are added into the equation, do the same unwritten rules apply to AVs as well? Referring to the accident that happened between the Google AV and the bus driver in 2016 [8], why was there misunderstanding between the two in the first place? Is it because the bus driver applied the same unwritten rules to the AVs? Or is it because there is an unwritten rule for AVs that they will always give way to other vehicles? Therefore, it is important to understand how people behave when sharing spaces with AVs to better program AVs as well as to make drivers aware of their difference in their behaviours.

People's unwritten rules on the road with AVs may be influenced by their trust in AVs. Tennant et al. [38] found a contradictory finding - while majority of the drivers agreed that AVs are safer than human drivers, they felt uncomfortable in boarding or driving alongside one of them and would prefer human drivers to be in control of the vehicle. The concept of trust seems to be an underlying factor that influences people's attitude and perception on AV and might in turn affect how they interact with them. This present study argues that people's trust might be varied with the level of anthropomorphism of the agents who were 'in control of' the vehicle. Indeed, Lee et al.'s study [19] found that participants who were observers outside the vehicle elicited higher level of trust to a more human-like agent than a nonhuman-like agent due to a higher sense of social presence. Thus, considering that it is anticipated that AVs would be driverless/ agentless in the future, it is possible that people may evoke less trust in AVs, thus more willing to negotiate with them. Therefore, in this study, through adopting a fictional road scenario proposed in Tennant et al.'s study [38] where a human driver has to negotiate road spaces with another vehicle, it is expected that participant will be more willing to negotiate with AVs than MVs.

Eastern and Western Cultures in AVs. Previous studies have compared perceptions on AVs in different countries. Schoettle and Sivak found that participants from China conveyed a

more positive attitude towards AVs than some western countries such as the U.S. i.e. 26% Chinese participants think that fully AVs will not be safe versus 47% U.S. participants [30]. In Continental's 2013 report [33], more respondents from China (79%) than the U.S. (41%) agreed that AV is a useful invention. However, at the same time, more people from China (74%) than the U.S. (50%) believed that AVs are not going to function reliably, contradicting with their positive attitudes. However, we can see that on average people from China conveys a more positive attitude towards AVs.

With the fairly clear difference between the East and the West, there has been attempts to explain the difference with existing theories. The classic approach to explaining cultural differences is Hofstede's individualism versus collectivism theory [12]. Hofstede [12] suggested that one of major cultural differences between western and eastern culture is that westerners tend to think in an individualistic and atomic way whereas easterners tend to consider collectivistic and holistic factors [12, 23]. China and Hong Kong were defined as a highly collectivistic country and region, where people are more likely to define themselves by the group they belong to and the U.K. was defined as a highly individualistic country, where people are more likely to act in their own and their family's interest. Therefore, according to this theory, people from Hong Kong and the U.K. may have different considerations on the road i.e. Hong Kong people may pay more attention to how they influence others and the larger society than British who may only pay attention to their own and their family's lives. Therefore, in addition to the fact that people from China are more positive about the development of AVs [6, 10, 30, 33], it is likely that people from an eastern background would be more considerate of other vehicles including AVs than people from a western background.

On the contrary, researchers offered another interpretation of Hofstede's individualist versus collectivist theory [12]. One example is Awad et al.'s study [2] where they investigated into variations of the *trolley problem*. A typical trolley problem is that participants are given two scenarios of an unavoidable fatal traffic accident (e.g., killing 5 pedestrians or 1 pedestrian) in this case involving an AV, and are instructed to choose one outcome from the two. Authors argued that this essentially allows researchers to infer what people's ethical priorities are like in different countries. They found that participants from western countries e.g., the U.K. and the U.S., are more likely to spare more lives than eastern countries e.g., Japan, South Korea and China. Authors argued that it is due to the fact that each individual lives are being valued more in individualistic thinking than collectivistic thinking. What also follows through the argument was that it was also found that Chinese participants are less likely to spare pedestrians than passengers and themselves than western participants, making them more likely to act in their own self-interest. Therefore, it seems like depending on the interpretation of the same socio-cultural theory, explanation can be different.

Having explored the potential interpretations, we realised how challenging it is to evaluate and predict how the cultural differences may influence how people negotiate road spaces. However, we believe that Chinese participants' positive attitudes towards AVs might have come about from wanting to solve a collective issue i.e., congestion, instead of an individualistic issue i.e., fatal accident. China is experiencing a serious traffic issue and is resorting to unthinkable solutions such as 'straddling buses' [9]. Therefore, in terms of negotiating road spaces, solving a collective problem, not only will participants from Hong Kong be more willing to negotiate road spaces with other vehicles, in particular they will be more willing to negotiate with AVs than U.K. participants.

Decision for Oneself or for Others. Trade-off behaviours on the road with one's own interest when facing AVs have also been examined using *the trolley problem*. Bonnefon et al. [3] studied it in a different set of scenarios outside of cultural contexts. They illustrated a social dilemma phenomenon [5, 40] whereby people acknowledge the best result for the greater good but still prefer outcomes that are in favour of their own self-interest. They demonstrated this consistently in several experiments. One of them was by asking participants to rate the morality of an AV that would react in a certain way and how likely they would buy that particular AV. While they found consistent results in most results (i.e., the more the morally correct the AV, the more likely a person would buy the AV), inconsistent finding was found in the algorithm that sacrifices the passenger to save 10 pedestrians' lives. It's morality rating was high but people's likelihood to buy it was low. This shows that utilitarian AVs were morally acceptable to respondents but they would not purchase one themselves because it will put them in harm's way. Therefore, in light of Bonnefon et al.'s [3] findings, this present study suggests the social dilemma may be present in drivers' negotiating behaviours. We test this by presenting scenarios so participants would either view themselves (i.e., first person) or someone else (i.e., third person) as the driver who negotiates with an opposite vehicle. We propose that participant will act more in their self-interest when they imagine themselves as the driver than as someone else being the driver.

One limitation of running a survey-type study with subjective topics like this however is that participants' responses may subjected to social desirability bias (SDB), whereby they may have responded to the questions in a manner that reflects good behaviour inconsistent with their actual behaviour [25]. Two main reasons that were identified by social psychologists are impression management and self-deception [25, 26], where the former is close to lying or

providing false impression to others; and the latter is an unintentional overestimation their performance [21]. Past research showed using the Driver Social Desirability scale that impression management was negatively associated with undesired traffic behaviour such as accidents and penalties [1, 17] and self-deception was positively correlated with self-confidence of one's driving performance and decisions [17]. Although some studies argued that in fact SDB does not affect considerably on the accuracy of people's self-reports of driving behaviours [16, 36], most of the authors agree that at least to some extent it may cause a problem when measuring factual detail about driver's behaviour [1, 16, 17, 36]. Thus, in this study, measuring responses in third person perspective can be viewed as participants' true negotiation behaviour if results for desired behaviours measured in first person perspective was inflated. Therefore, it is noted that participants might provide more socially desirable answers in first person perspective than in third person perspective

3 GOALS AND HYPOTHESES

The present study aims to investigate how different factors may influence people's trust in AVs and in turn affect how they feel and respond when they encounter AVs. This study would like to firstly examine how safe people feel about AV after reading a news report of an accident where information of different nature is presented. Secondly, this study examines how people would negotiate road spaces with AVs and with other drivers in multiple different aspects i.e., comparing the types of vehicle, multi-cultural differences and first versus third person point of view (POV).

Therefore, one prediction concerning perceived safety in in different types of reports is made in the current study. With reference to the dual-processing model, it is expected that AVs will be perceived as less safe in the condition that focuses on reporting subjective information e.g. details about victim than in the condition that focuses on reporting objective information e.g. statistical data. Secondly, three predictions concerning how people negotiate on the road were made. As anthropomorphism of the agent who is in control of the vehicle influences people's trust in the vehicle [19], it is expected that participant will be more willing to negotiate with AVs which they trust less than MVs. As people from the eastern background tend to consider holistic factors [12] and convey more positive attitudes towards AVs [33**?**] than those from the western background , it is predicted that Hong Kong participants will be more willing to negotiate with other vehicles including AVs on the road than U.K. participants. Due to the social dilemma phenomenon [3], people will be more likely to negotiate more in their own favour if they were the driver than if they were not the driver.

4 METHODS

Participants

All participants were paid survey participants and drivers that held a driving license valid in either the United Kingdom or Hong Kong. This survey study was composed of the two experimental parts and were completed by different numbers of participants. While all participants completed the first experimental part of the study, only majority of them completed the second one. See Table 1 for detailed participant demographics.

	Part 1		Part 2	
	Before Filtering ($N = 633$)	After Filtering ($N = 600$)	Before Filtering ($N = 408$)	After Filtering ($N = 399$)
	n	*n*	*n*	*n*
Gender				
Male	326	309	222	215
Female	307	291	186	184
Nationality				
British	421	400	202	199
Hong Kong	212	200	206	200
Ethnicity				
White	409	400	201	199
Chinese	214	200	206	200
Other ethnicities	10	0	1	0
Age (years old)				
18-24	41	39	31	31
25-34	120	114	93	91
35-44	128	116	95	90
45-54	84	79	56	56
55-64	95	93	56	54
> 64	165	159	77	77

Table 1: Demographic Information of Participants Before and After Data Filtering

Design

Part 1: Perceived Safety of AV. The first part of the study is a between-subject design. The independent variable is whether a news report of a traffic accident involving an AV focused on reporting subjective information i.e., about the victim, or factual information i.e., of statistics and facts about AVs. The dependent variable is how safe participants perceived AVs which was measured by a 5-item Perceived Safety scale.

Part 2: Negotiating Spaces with AV. This second part of the study is a 2× 2× 2 (Nationality × POV × Opposing AV/MV) mixed factorial design. The first between-subject independent variable is participants' nationality which is either

British or Hong Kong. The second between-subject independent variable is the POV that participants were assigned to view the road situation i.e., they were given descriptions, diagrams and questions that were presented in either 1st person POV or 3rd person POV. The last independent variable which is within-subject is the level of automation of the opposing car that is coming from an opposite direction i.e., MV or AV. The dependent variable is a series of participants' reactions and behaviours that indicated whether they were willing or unwilling to negotiate with the opposite vehicle.

Materials

A modified version of the questionnaire that was developed by Tennant et al.'s study [38] to measure people's perception on autonomous vehicles was used. The questionnaire was set up on the online survey platform, Qualtrics.

Two attitude scales were measured in this study which are presented in Appendix A. The first one is the Technological Optimism scale (10 questions, Q1-10), which measures how optimistic participants are about technology and its development, including 3 items (Q8-10) that measures how risky they think the use of technology is. The Likert-Type scale set 1 as *strongly disagree* and 5 as *strongly agree* and 6 as *don't know*. Q4 and Q10 were subjected to reverse scoring between 1-5. The overall reliability of Technological Optimism items was high i.e., $\alpha = 0.785$. The reliability for British participants was found to be high as well, i.e., $\alpha = 0.730$ but was low for Hong Kong participants i.e., $\alpha = 0.470$.

The second one is the Driving Sociability scale (12 questions, Q11-22) which measures how cooperative or competitive participants are with other drivers on the road. The four items (Q11-14) focused on the participant's general social respect and responsibility on the road (measured on a Likert-Type scale of 1 being *strongly disagree*, 5 being *strongly agree* and 6 being *don't know*). They formed the scale with Q15-22 that ask how often specific social situations apply to participants' personal driving experience (with Likert-Type scale of 1 being *never*, 5 being *always* and 6 being *don't know*). Q11, Q12, Q14, Q16, Q18 and Q20 subjected to reverse scoring between score 1-5.

Part 1: Perceived Safety of AV. Two imaginary news report vignettes that were written by the researcher were used. While both of the news reports described a traffic accident involving an autonomous vehicle and the death of a victim, one of them was victim focused ('Victim' condition) and the other was statistically focused ('Statistics' condition). Both openings of the news reports were the same i.e. reporting the occurrence of an accident between an AV and a pedestrian who unfortunately did not survive the event. The two paragraphs were then written differently for the rest of the passage.

In the 'Victim' condition, the vignette then reported what allegedly happened to the victim before and after and at the moment of the accident, and it ended with a brief sentence stating that since the use of autonomous vehicle, fatalities and accidents have been significantly reduced, to avoid strong bias in favour of the subjective information.

In the 'Statistics' condition, the news report described the advanced technology that was equipped on the AV e.g., 3D mapping, as well as stating the significant numerical figures of the accidents and fatalities that had been reduced in over a hypothetical period and that this was only the second time that an AV has had an accident this year. See Appendix B for the complete vignettes.

A 5-item Perceived Safety scale was then used to measure how safe participants think AVs are (with the Likert-Type scale of 1 being *strongly disagree*, 5 being *strongly agree* and 6 being *don't know*. See Appendix C for the items. The statements were created by the researcher through adopting risk-related adjectives suggested by Hayes, Perander, Smecko and Trask [11]. Reliability between the items was consistently high overall, $\alpha = 0.854$, for British, $\alpha = 0.884$, and for Hong Kong, $\alpha = 0.751$.

Part 2: Negotiating Spaces with AV. In the main experiment, eight different diagrams were used. Figure 1a and 1b were used in the scenarios when participant's car/Car A was moving; Figure 1c and 1d were used in the scenarios when participant's car/Car A was being blocked. Figure 1 shows a set of the diagrams which were used in the 1st person POV condition; *"Your Car"* was being replaced with *"Car A"* in the 3rd person POV condition. The description of the scenario and the phrasing of the questions also varied according to the POV condition e.g. *"you"* in 1st person POV versus *"driver in Car A"* in 3rd person POV. Separate sets of 5 questions were given for the moving and blocked scenarios (See Table 2 for the complete set of questions).

Procedure

At the beginning of the questionnaire, participants' consent was taken to participate in the study that received ethical approval from the Ethics Committee of 'Anonymous'. Afterwards, their demographics were collected i.e., age, whether they have a valid driver license or not, gender, nationality, ethnicity, the country they usually drive in and the number of years they have had their license.

Participants were then asked to answer questions which are on the 10-item Technological Optimism scale and the 12-item Driving Sociability scale.

Part 1: Perceived Safety of AV. The questionnaire then moved on to the first experiment. In this section, participants were presented with one of the two imaginary news report vignettes which was either subjective i.e., victim-focused (the

'Victim' condition), or Objective i.e. statistically focused (the 'Statistics' condition). They then filled in the 5-item Perceived Safety scale.

Part 2: Negotiating Spaces with AV. Now, participants proceeded the second experimental section. They were presented with hypothetical road situations one by one which were described both in words and with diagrams. The road situations involved two cars which were driving in different directions on a two-lane road, with one moving and one being blocked, negotiating spaces with one another.

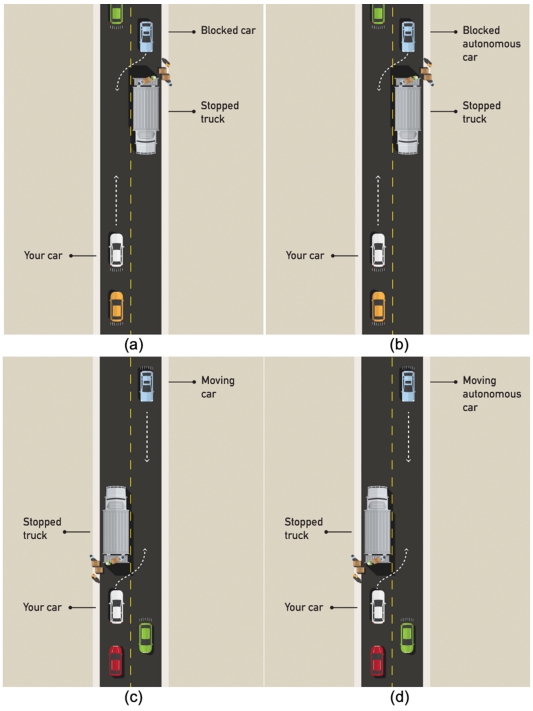

Figure 1: Diagrams for Different Conditions in 1st Person POV

Note: The label "Your Car" is replaced with "Car A" in 3rd person POV condition.

Participants who were either from Hong Kong or from the U.K. were presented with four road scenarios where they took turns to be the moving car and to be the blocked car (i.e., presenting scenarios in a manner that randomly alternates Figure 1a and 1b with Figure 1c and 1d). Participants then rated the set of statements according to the scenario they receive (See Table 2 for the different sets of questions). Participants received the scenarios i.e., the description of the scenario, the diagrams and the phrasing of the questions, either in 1st person POV and in 3rd person POV.

In half of the moving and blocked scenarios, the opposite car was a manual driving car (See Figure 1a and 1c); and in the other half, the opposite car was an AV (See Figure 1b and 1d). The conditions were counterbalanced between participants.

5 RESULTS

Data Filtering

Before data was analysed, straight-lining data e.g. respondents who rushed through the questionnaire or repeatedly provide the same answers were removed. Also, for those who neither usually drove in the U.K. or in Hong Kong were removed. Demographics of remaining participants are presented in Table 1. When studying attitudes towards unfamiliar technological objects, *'Don't Know'* (DK) answers are as important as agreement or disagreement. However, for the purposes of scale building we have to treat DKs responses as missing values. Typically DKs represented between 6.52% and 8.66% of responses.

Data Analysis

Analyses were performed on the 5-item Perceived Safety scale between the 'Victim' and the 'Statistics' conditions for the first experimental section and then on the 10 items in the second experimental section according to the mixed factorial design. Data from both sections were also analysed with relevant attitude scales to draw further meaning on the data.

Part 1: Perceived Safety of AV

A one-way ANOVA was performed on the Perceived Safety scale between the 'Victim' and 'Statistics' conditions. The 'Victim' group ($M = 2.716, SD = 0.699$) perceived AVs as significantly less safe than the 'Statistics' group ($M = 2.900, SD = 0.803$) , $F(1, 547) = 5.37, p = .021, \eta_p^2 = 0.010$. There was no significant difference between the nationalities in their scores, $F(1, 547) = 0.15, p = .698, \eta_p^2 = 0.000$.

Correlation with Technological Optimism Scale. Further analysis was performed in relation to the Technological Optimism scale that includes technological risk perception items. Bivariate correlations test shows that Perceived Safety scores were significantly correlated with Technological Optimism scale, $r = 0.347, p < .001$.

Part 2: Negotiating Spaces with AV

$2 \times 2 \times 2$ (Nationality $\times$ POV $\times$ Opposing AV/MV) mixed factorial ANOVAs were performed separately on the 10 items (5 Moving items, 5 Blocked items). The results of the main effects of each independent variable are shown in Table 2. A higher Likert score represents a stronger agreement to the statements.

Opposing AV/MV. There was a main effect of Opposing AV/MV only for 'right of way' (M2) item. Participants were more

	Opposing AV/MV (*AV* VS *MV*)		Nationality (*British* VS *Hong Kong*)		POV (*"I"* VS *"the driver in Car A"*)	
	F	η_p^2	F	η_p^2	F	η_p^2
Behaviour - Willing to Negotiate / Considerate						
Moving						
M5. I would help the car if it didn't inconvenience me very much	0.13	0.000	2.97	0.008	8.76*	0.023
Blocked						
B2. The other car ought to keep moving because it has the right of way	2.78	0.007	11.7*	0.029	2.63	0.007
B3. I would wait until there was a clear gap in the oncoming traffic	2.83	0.007	36.7**	0.087	1.74	0.004
B5. If the other car lets me proceed in this situation, I would be more likely to help another vehicle progress in a similar situation	0.08	0.000	0.011	0.000	11.3*	0.029
Behaviour - Not Willing to Negotiate / Less Considerate						
Moving						
M1. I would not slow down to let the blocked vehicle pass around the truck in front of me	0.18	0.000	1.00	0.003	41.47**	0.936
M2. I would keep driving, because it is my right of way	37.2**	0.09	0.02	0.000	37.0**	0.09
M3. I would keep driving if I could see in my rear-view mirror that there is a gap behind me	0.06	0.000	5.31**	0.014	2.72	0.007
M4. The blocked car ought to be able to communicate with me to ask to be let out	0.36	0.001	22.8*	0.058	6.03*	0.016
Blocked						
B1. I would be annoyed if the moving car did not let me out	0.02	0.000	38.6**	0.092	3.59	0.009
B4. I would nudge out into the oncoming traffic lane to encourage the other vehicle to let me through	0.11	0.000	30.5**	0.074	0.78	0.002

Table 2: Mixed Factorial ANOVA F Ratios Between Conditions in Opposing AV/MV, Nationality and POV
$^{*}p < .05$. ** $p < .001$., $df = 1, 372$

likely to keep driving when facing an AV ($M = 2.73, SD = 1.027$) than facing a MV ($M = 2.38, SD = 0.930$) .

Opposing AV/MV× Nationality. An interaction was also found in the 'communicate' (M4) item between Opposing AV/MV and Nationality $F(1, 372) = 5.66, p = .018, \eta_p^2 = 0.015$. Simple effect analyses using paired t-tests showed that British drivers are more inclined to think that the opposite blocked vehicle needs to communicate with them to be let out if it was a MV ($M = 3.02, SD = 1.061$) than if it was an AV ($M = 2.89, SD = 1.029$), $t(181) = 2.21, p = .028, d = 0.164$, but not Hong Kong drivers.

There was also an Opposing AV/MV × Nationality interaction in the 'being annoyed' (B1) item between , $F(1, 383) = 7.52, p = .006, \eta_p^2 = 0.019$. Paired t-tests indicated that Hong Kong drivers less likely to be annoyed if the opposite vehicle was a MV ($M = 2.38, SD = 0.868$) than than if it was an AV ($M = 2.51, SD = 0.894$), $t(197) = 1.99, p = .049, d = 0.141$, but not British.

Nationality. Significant main effects of Nationality were found in six of the items (illustrated in Figure 2). The item which shows that British significantly are more considerate of the opposite vehicle than Hong Kong participants is the 'keep driving gap' (M3) item. The other items which show that Hong Kong are significantly more considerate of the opposite vehicle than British participants are the 'other's right of way' (B2) item, the 'wait for gap' (B3) item, the 'communicate' (M4) item, 'being annoyed' (B1) item and the 'nudge out'(B4) item.

POV. There were significant main effects of POV in five of the items (illustrated in Figure 3). The item where people are more considerate of the opposite vehicle when information was presented in 1st person POV than 3rd person was the 'communicate' (M4) item. The items where people are more considerate in 3rd person POV than 1st person are the 'help blocked' (M5) item, 'help next blocked'(B5), the 'not slowing down' (M1), the 'right of way'(M2).

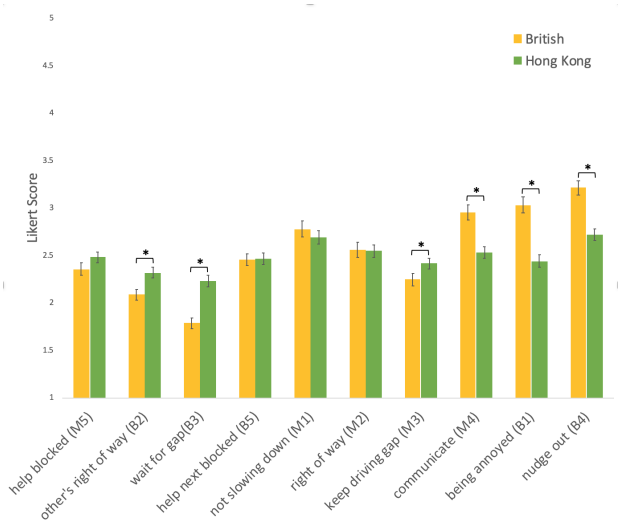

Figure 2: Mean Likert Score responses for British and Hong Kong participants
1 = *strongly disagree*, 5 = *strongly agree*

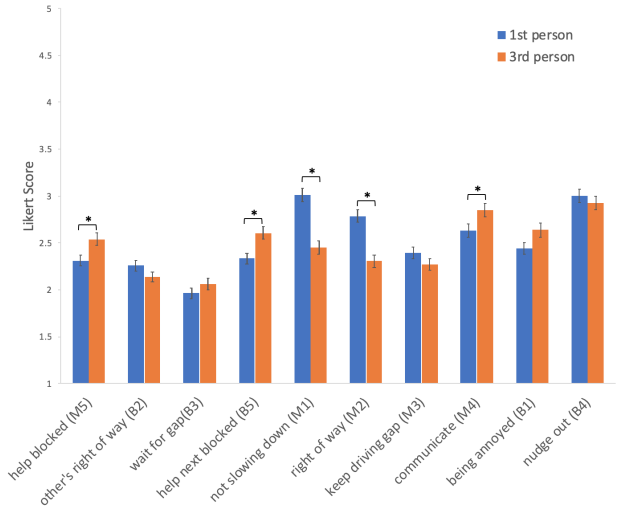

Figure 3: Mean Likert Score responses for 1st person and 3rd person POVs
1 = *strongly disagree*, 5 = *strongly agree*

Correlation with Driving Sociability Scale. Further analyses running the bivariate Pearson Correlation test on the Driving Sociability scale were carried out. Negative correlation was found in the scale's association with 'other's right of way' (B2) (i.e., Manual Driving: $r = 0.224, p < .001$; Autonomous: $r = 0.217, p < .001$) and 'wait for gap' (B3) (i.e., Manual Driving: $r = 0.454, p < .001$, Autonomous: $r = 0.476, p < .001$). Positive correlation was found the scale's association with 'being annoyed' (B1) (i.e., Manual Driving: $r = -0.383, p < .001$; Autonomous: $r = -0.340, p < .001$) and 'nudge out' (B4) (i.e., Manual Driving: $r = -0.294, p < .001$; Autonomous: $r = -0.387, p < .001$). Therefore, the higher that people scored in the Driving Sociability scale, the more they elicited considerate behaviours towards both AVs and human drivers.

6 DISCUSSION

The present study explored how different subjective and cultural factors may play a role in affecting people's attitude towards AVs. We firstly investigated people's concern in AV's safety after reading a news report of an accident with different type of information - 'Victim' versus 'Statistics'. As expected, the report where more victim's information was mentioned resulted in AV being perceived as less safe than the report where the focus was on statistical information. Secondly, this study explored several different aspects in how people react to other vehicles and AVs in a shared space on the road i.e. with AVs versus MVs, between eastern and western cultures and between the decisions for oneself and for others. It was expected that people would be more willing to negotiate with AVs than MVs, that British would be less considerate of others including AVs than Hong Kong people and that they would be less considerate in first person POV than third person POV. The findings found that drivers did not convey differences in attitudes in all but one negotiation behaviour i.e. "I would keep driving, because it is my right of way". Result for quite a few negotiation behaviours supported the cultural hypothesis. Findings from manipulating POV of the scenarios reflected that participants considered other drivers as more considerate and polite than themselves, unaffected by SDB.

Safety Ratings: Subjective versus Logical Reasoning. The difference in perceived safety between processing subjective information and factual information shows evidence for the dual-processing model [14]. The information about the victim was able to elicit a stronger feeling of insecurity towards the AV than that of numerical figures and facts about AVs, showing that different reasoning mechanisms (i.e., affective versus logical) were used. However, that being said, the objective information did not lead to participants to feel safe on average. Instead, the scores in both conditions leaned towards finding AVs unsafe (i.e., less than 3). Despite the effort of factual information in conveying unbiased information, people still felt unsafe towards AVs. Trust was hard to be restored in AVs once damaged. We therefore can see that people are less forgiving towards AVs. This is to some extent consistent with the Dietvorst et al.'s study [7] where they found that people lost trust in an algorithm quicker than in human. One reason might be that people have higher expectations in algorithms to make objective decisions than

human [20]. Systematic calculations in an algorithm in theory should not make mistakes if they are created to replace human's responsibilities. Therefore, as AVs are expected to reduce the high amount of traffic accidents and fatalities that are caused by human errors, when it does not do what it claims, the damaging effect on their trust might be serious. This explains participants' persistent level of insecurity towards AVs in this study. It would be interesting to examine whether higher expectation was actually applied to AV by testing replacing AVs with human error in the vignettes in future studies.

Perceived safety's positive correlation with technological optimism showed that people who were more optimistic about technology and less worried about potential technological risk were tend to express a relatively lower level of insecurity towards AVs after reading the vignettes. This shows that not only were people affected by the nature of the news reports, their levels of security might have also been determined by how optimistic they are and how risky they think technologies are. As the finding reported a relatively low average Technological Optimism score, once again showing support for Dietvorst et al.[7] and Logg's studies [20], people's pessimistic perception and high risk concerns about technology might have in fact influenced them to think that AV was not safe. This provides new insight into how people's lack of confidence in technology is related to their perception of safety on this new technology. Possible implication on alleviating safety concern about AV should therefore focus on tackling people's attitude and encourage them to be more optimistic towards technology in general instead of tackling people's perception on AV alone.

Negotiation: AVs versus MVs. Understanding other driver's perception on AV provides us insight into how social interactions with AVs may happen on the road. By adopting Tennant et al.'s questionnaire [38], this study was able to gain new insight into how people reacted when negotiating with AVs and with MVs. The present findings showed that there were no differences between reacting to AVs and MVs except for one behaviour, i.e., people are more likely to keep driving because they think they have the right of way when they were facing an AV than a MV. It appears that drivers applied similar unwritten rules discussed in Tennant et al. [37] onto other drivers and AVs. The hypothesis which stated that people would be more willing to negotiate with AVs than MVs is therefore not accepted.

This hypothesis was formulated on the basis that people would be less trusting towards AVs than humans due to lower anthropomorphism according to Lee et al. [19] so drivers would be more willing to give way to AVs. However, it should be noted that Lee et al. [19] put more effort in manipulating the level of anthropomorphic traits in their driving agents e.g., their appearances and verbal communication and level of control etc. In the present study, we put lower emphasis on anthropomorphism and did not control for how participant should picture what the AV should look like. This allowed room for variation i.e. participants might have imagined the AV with a driver, no driver or with a robotic agent, affecting people's trust in the AVs and in turn their self-reported responses. This design decision was initially made because how fully AVs will look in the future still remain unclear in the field e.g., with of without a driver/agent and/or a steering wheel [29] etc. Future studies may get clarification into whether giving a clear image of what AVs may look like may make a difference to their responses or not. The present study also did not directly measure people's perceived trust like Lee et al. [19] did. Therefore, without a measure of trust, it is hard to infer whether people actually trusted AVs to the same extent as MVs. Future investigation can explore people's negotiation behaviours incorporating a measure of perceived trust.

Another potential reason might be because participants were unable to imagine what their interaction would be like with AVs due to their lack of encounters with AVs in real-life, raising the possibility that drivers would be surprised by differences when actually interacting with AVs. It was suggested that the imagination of future events is formulated depending on the memories and representations of past experiences [28, 34, 35]. This might have therefore limited people's imagination of their interactions with the AVs as they have not had a past experience with AVs that they could reference to. The only experience they could refer to is that with other drivers. Therefore, the present participants might have based their imagination of AVs on their past encounters with other drivers and did not think that the two kinds of vehicles would bring about significantly different experiences.

Negotiation: Cultural Differences. While there wasn't an overall differences for most negotiation behaviours in Opposing AV/MV, there were two cultural-specific differences in the behaviours. It was found that British participants were more forgiving towards blocked AVs than blocked MVs in terms of their level of initiatives they should take to communicate with participants to be let out. Moreover, when they were blocked, Hong Kong drivers were less annoyed at the MV than the AV for not letting them out. Though the results have relatively low effect sizes, the two behaviours suggest a possible pattern - people from the U.K. are more willing to negotiate spaces with AVs than MVs compared people from Hong Kong. This is inconsistent with what was predicted. It was expected that due to the positive attitude that Chinese people conveyed towards AVs [30] and their collectivistic

thinking [12] that they would be more willing to negotiate with AVs. However, the weak pattern does not allow us to draw any meaningful conclusions. It is suggested that the pattern can be revisited over time as AVs become more common and more readily available to the public.

Regardless of the vehicle type of the opposing car, Hong Kong participants were found more considerate of other vehicles i.e., both AVs and MVs, than British participants in five out of six significant items. This is found consistent with Hofstede's theory i.e. individualism versus collectivism [12]. In fact, people from an eastern collectivistic background would be more likely to consider holistic factors in negotiation situations than those from a western individualistic background. More specifically, while Hong Kong participants were found more considerate overall, they were also more willing to negotiate with AVs than British. We know this because no significant interaction indicated that the cultural difference was specific to a certain level of automation. Therefore, the present findings once again showed that Chinese/Hong Kong people are more positive towards AVs than British people.

Negotiation: First Person versus Third Person POVs. The hypothesis that people viewing scenario in a first person POV will be less considerate than people viewing scenario in a third person POV is accepted. The results shows that participants in this study did not overstate desired behaviours in themselves and are unaffected by SDB. In four out of five significant items, it was found that participants who viewed in first person POV were less willing to negotiate with other vehicles than those who viewed in third person POV. This suggests that people might have a higher expectation of other drivers to behave considerately and politely than themselves. They recognised that it is more appropriate to be flexible in terms of negotiating spaces with other people but they would not do it themselves. This finding is consistent with Bonnefon et al.'s social dilemma phenomenon where people are not accepting of a scenario that they identified as a more morally correct themselves [3]. This is a question to think about for the future of AVs. If people are acting in their own self-interest, does it mean that AVs will have to give way all the time? Unlike humans who may provide hand gestures, make eye contact and other social signals, AVs are unable to do so to signal the other driver. A whole new sets of unwritten rules for drivers i.e., getting used to new ways of signalling with AVs, will have to be developed both by regular drivers and AV designers.

Negotiation: Driving Sociability. Making use of the attitude scales suggested Tennant et al.'s research [38], this study is able to provide new insight into how people's attitudes towards technology may influence their driving behaviours. The present study demonstrated a positive correlation between Driving Sociability scale and two considerate behaviours; and a negative correlation between Driving Sociability scale and two less considerate behaviours. Therefore, we can see that the more cooperative participant was in driving, the more likely they were to exhibit considerate behaviours in negotiation. This provides new understanding into how people's negotiation behaviour may potentially depend on how cooperative or competitive they are on the road with other drivers.

Limitations

One limitation in the Perceived Safety part of the study is that more news reports could have been explored, particularly, positive incidents e.g., a near-miss accident. This is because upon reading a news article about a fatal accident, it was not surprising that participants might have thought that AVs are unsafe in general. After all, a person was killed in the hypothetical situation. Therefore, a positive scenario showing that AVs actually work as it claimed will be able to provide us more neutral understanding to how the information may affect people's decisions.

The first limitation of the Negotiation part of the study is that the diagrams of the scenarios were all depicted in an aerial perspective. In real life, the view of drivers would be restricted and drivers might not be able to tell whether there is blocked or oncoming vehicle on the other lane, let alone the type of vehicle. Therefore, unless future technologies transmits these kinds of information to drivers, current drivers might not react in the way that the present participants reported they would in real-life. Future study may consider contrasting first person view i.e., view from the driver seat, and an aerial perspective to improve ecological validity.

7 CONCLUSION

This study suggests that people's trust and behaviours may vary depend on how the information was presented and how participants were placed in different situations. This study demonstrated a persistent safety concern towards AVs in general, despite an improved perceived safety in AVs after reading objective news report. Therefore, the news media should recognise the framing effect and handle these accidents carefully. Moreover, through investigating drivers' unwritten negotiation rules with AV, cultural differences and different POVs, it is shown that the two-way interaction between drivers and AVs is more dynamic and less predictable than we thought. This study has great implications for the literature (e.g., design better diagrams resembling closer to reality), and in real-life (e.g., safety concerns about AV should be reduced by tackling people's attitude and risk perception towards technology). Exploring people's social responses and underlying attitudes in this study allowed us to gain insight into how we trust and interact with AVs.

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A TECHNOLOGICAL OPTIMISM SCALE AND DRIVING SOCIABILITY SCALE.

To what extent do you agree or disagree with the following statements?

(1) Science and technology make our way of life change too fast
(2) I'm not interested in new technologies
(3) Science and technology are making our lives healthier, easier and more comfortable
(4) I enjoy making use of the latest technological products and services when I have the opportunity
(5) The idea of artificially intelligent robots is scary
(6) If I'm in a plane I need to know the pilot is there to take over from the autopilot if necessary
(7) I am worried about where all this technology is leading
(8) We have no option but to adapt to the new technologies that are coming
(9) Machines are taking over some of the roles that humans should have
(10) When my safety is involved I'm happy to rely on technology
(11) The other motor vehicles all have the same right to be on the road
(12) As drivers we all need to help keep the traffic flowing
(13) Each driver has to prioritise their own progress over other people's
(14) As drivers we all need to co-operate with the other drivers on the road

Please give us your opinion on the following statements, by telling us for each one how often it applies to you.

(15) I find that other drivers try to bully me on the road
(16) I don't mind being at the back of a queue of traffic, because we all get there in the end
(17) When I am in a queue of traffic that is merging with another I just force my way in
(18) When another driver has made way for me I feel it's my turn to make way for someone else later on
(19) If another driver impedes me I will impede another driver later on
(20) When queues of traffic are merging drivers should take turns
(21) It's ok for someone to push into a queue if they are in a hurry
(22) If it slows me down I won't help other drivers

B VIGNETTES FOR PART 1 (PERCEIVED SAFETY) OF THE STUDY

Imagine a scenario in the future where driverless vehicles are permitted to drive on the road. Please read the imaginary passage below and answer the questions accordingly.

Victim condition

On 27 September, a car accident occurred involving an autonomous car crashing into a pedestrian named Jordan Brown who abruptly ran onto the road. Unfortunately, Brown did not survive the event. Preliminary police investigation indicated that Brown who dressed in a suit was heading for a job interview and was unable to reach the venue due to unfortunate event. It was reported that she was not aware of the situation of the road and was allegedly trying to obtain a document that fell on the road. Further investigation is yet to confirm the responsibility of the unlikely event of an autonomous car crash. Since autonomous cars are driven on the road, the number of accidents and fatalities caused by human error have been largely reduced due to its high accuracy in responding to road situations.

Statistics condition

On 27 September, a car accident occurred involving an autonomous car crashing into a pedestrian named Jordan Brown who abruptly ran onto the road. Unfortunately, Brown did not survive the event. Autonomous vehicles are designed and programmed with algorithms to be able to monitor their surroundings using 3D mapping, radar and laser ranging technology and react instantly when any rare event is detected. The actual reason why the autonomous vehicle had

not been able to avoid the unlikely event is yet to be confirmed. In the 6 years since autonomous cars were permitted on the road, total road traffic accidents have been reduced by 22%, averting approximately 1.07 million crashes in the 12 countries where they have been introduced as well as avoiding estimated 55299 fatalities. This accident is the second accident this year where an autonomous vehicle is involved.

C PERCEIVED SAFETY SCALE

To what extent do you agree or disagree with the following statements?

(1) Autonomous vehicles are safe.
(2) Autonomous vehicles driving on the road are a concern since they may hurt someone easily.
(3) Autonomous vehicles driving on the road are worrying.
(4) Autonomous vehicles are dangerous.
(5) Autonomous vehicles are more dangerous than traditional vehicle.