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Factors influencing safety perceptions of sharing roadways with autonomous vehicles among vulnerable roadway users

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ABSTRACT

Introduction: The operation of autonomous vehicles (AVs) on public roadways affects the safety of vulnerable roadway users, such as pedestrians and bicyclists. This research contributes to the literature by investigating vulnerable roadway users' safety perceptions on road sharing with AVs. *Method*: This study analyzed the survey responses of pedestrians and bicyclists in Pittsburgh, Pennsylvania, collected by Bike Pittsburgh (Bike PGH) in 2017 and 2019. First, this study investigates how pedestrians and bicyclists perceive safety regarding road sharing with AVs. Second, the study examines how the safety perceptions of pedestrians and bicyclists regarding AVs might be changing over time. Non-parametric tests were applied to compare the safety perceptions of pedestrians and bicyclists across different characteristics, experiences, and attitudes, considering the ordinal nature of the AV safety perception data. An ordered probit model was estimated to better understand the factors influencing safety perceptions regarding road sharing with AVs. *Results:* The study findings suggest that higher exposures to AVs are associated with improved safety perceptions. In addition, respondents with a stricter attitude toward AV regulations perceive road sharing with AVs as less safe. Respondents whose opinion regarding AVs did not worsen due to the pedestrian/bicyclist involved AV accident in Arizona have higher safety perceptions. *Practical Applications:* Policymakers can use the findings of this study in developing guidelines to ensure safe road sharing and develop strategies to sustain active transportation usage in the future AV era.

1. Introduction

The evolution in autonomous vehicle (AV) technologies has significantly disrupted surface transportation systems and services. AV technologies are expected to improve traffic safety, as AVs' wide-scale deployment can eliminate most traffic crashes involving human error (Hilgarter et al., 2020). AV technology testing on public roadways has been started in many countries worldwide (Broggi et al., 2015). In recent years, AV technology development companies (e.g., Waymo) have started testing AVs on public roadways without a test/safety driver (i.e., absence of pilot and/or co-pilot to monitor AV operation who would take vehicle control for any AV technical or other issues; Shoot, 2020). AVs' pilot operation on public roadways inevitably creates concerns for different roadway users' safety (e.g., pedestrians and bicyclists). Pedestrians and bicyclists are the most vulnerable groups of roadway users, as they travel relatively unprotected compared to the occupants of AVs or conventional vehicles. In addition, the interactions of AVs with pedestrians and bicyclists will be complex (Hulse et al., 2018). In March 2018, an Uber AV struck and killed a woman walking with her bicycle in Tempe, Arizona (Stanton et al., 2019), which was the first AV-involved pedestrian/bicyclist fatality. Although this AV incident raised questions over the safety and acceptance of AV technology, continuous improvement of AV technology via testing and performance assessment is critical to make the AV technology acceptable for mass deployment. AV safety has been regarded as a potential concern in the mass-scale deployment of AVs in literature besides public interests to use AVs (Penmetsa et al., 2019; Nair and Bhat, 2021). In these contexts, it is essential to investigate the safety perception of pedestrians and bicyclists on sharing roadways with AVs to improve user acceptance and accelerate the safe development of AV technology.

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2. Literature review

A large and growing body of literature investigated the general public opinions towards AVs, AV-related concerns, willingness to adopt AVs, and perceived safety while sharing the road with AVs as drivers of conventional vehicles and as AV riders (e.g., Hilgarter et al., 2020; Kyriakidis et al., 2015; Nair & Bhat, 2021; Liu & Xu, 2020). However, the assessment of pedestrians' and bicyclists' perceptions of AVs has been limited in past studies. According to Cavoli et al. (2017), less than 5% of total studies related to AV (20 out of 432 articles) explicitly discuss pedestrians or bicyclists. This literature review section focuses on reviewing past studies that have explicitly focused on pedestrians' and bicyclists' perceptions of AVs.

The topic of pedestrians' and bicyclists' perceptions of AVs has only recently attracted attention. A few recent studies have focused on exploring the perceptions of pedestrians and bicyclists using a survey-based approach. However, most of these studies have not explicitly targeted roadway users with experience in sharing a road with AVs. The American Automobile Association (AAA) survey conducted in 2018 reported safety concerns among 60% of the respondents regarding road sharing with AVs as pedestrians and bicyclists, which was higher than the AV road sharing related safety concern found among conventional vehicle drivers assessed in the 2017 AAA survey (AAA, 2017; AAA, 2018). On the contrary, Hulse et al. (2018) reported that pedestrians perceived road sharing with AVs as less risky than the passengers traveling in AVs, based on a 2016 online survey conducted in the United Kingdom. The authors also found that male and younger respondents showed greater acceptance of AVs than females and older respondents. The difference in AV safety perceptions arose, as many survey participants did not have active road sharing experiences with AVs as indicated by Brell et al. (2019). Sims et al. (2018) demonstrated that prior road sharing experiences with a travel mode is essential to gather more accurate perceptions of it. As AVs are still seen as a hypothetical future transportation mode by most people, they might not accurately anticipate the associated challenges without at least having some direct road sharing experiences with AVs (Penmetsa et al., 2019).

Deb et al. (2017) investigated pedestrian perceptions of AVs using a validated online survey questionnaire, which included three subscales (i.e., safety, interaction, and compatibility) and 16 survey items based on pedestrians' attitudes toward AVs, their social norms, their trust on AVs, their perceptions on AV compatibility with the existing transportation system, and perceptions of AV effectiveness in improving safety. Regression models were estimated to relate pedestrians' perceptions of different aspects of AVs (e.g., AV acceptance, perceptions of crossing road in front of AVs) with the subscale scores. Subscale scores of safety and interaction influenced pedestrians' perceptions of crossing streets in front of AVs. All of the subscale scores influenced AV acceptance among pedestrians. Reig et al. (2018) assessed pedestrians' trust in AVs by conducting interviews among 32 pedestrians who interacted with Uber AVs. Trust in AVs was influenced by respondents' knowledge of AV technology and the perception of the brand of AVs. Although AV technology familiarity among vulnerable roadway users was found positively associated with AV safety perceptions in most studies, some studies raised concerns on decision and action errors of AVs (e.g., errors in interpreting roadway information, errors in selecting vehicle speed) among respondents who are familiar with AV technology (Deka & Brown, 2021).

Very few survey-based studies were conducted on pedestrians and bicyclists who had the opportunity to have real-world road sharing experiences with AVs. To investigate perceived safety differences in driving, cycling, and walking near AVs, Pyrialakou et al. (2020) estimated three ordered probit models based on the stated preference survey conducted among the residents of the Phoenix metropolitan area in Arizona (a state that has allowed AV testing since 2015). The authors reported that cycling near AVs was perceived as the least safe activity compared to driving or walking near AVs.

In addition, a few studies assessed perceptions of Pittsburgh pedestrians and bicyclists using the BikePGH survey data. As previously mentioned, the U.S. Department of Transportation (USDOT) designated the city of Pittsburgh as 1 of the 10 proving ground pilot sites to facilitate AV testing and innovation (USDOT, 2017). By analyzing the 2017 BikePGH survey data, Penmetsa et al. (2019) concluded that exposure to AVs increased perceptions of AV road sharing safety among pedestrians and bicyclists. Das et al. (2020) applied multiple correspondence analyses using the same survey data and reported higher safety expectations among the pedestrians and bicyclists who shared road with AVs. The authors also found a marginally significant difference in safety perceptions among BikePGH members and the public. In a more recent study, Rahman et al. (2021) applied inductive and deductive data analysis techniques on the open-ended responses collected in the 2019 BikePGH survey to identify positive and negative perceptions and expectations related to regulation among pedestrians and bicyclists. The study found overall relatively higher positive than negative perceptions. Respondents perceived AVs as safer than human drivers but had concerns about AVs' slow and defensive driving. In terms of AV regulations, respondents suggested regulating AV movement in roadways, adopting AV safety assessment guidelines, and controlling AV companies' oversights. However, previous studies using the BikePGH survey data have not assessed AV safety perception differences over time or identified factors influencing AV safety perceptions. Jing et al. (2020), Saeed et al. (2020), and Saeed (2019) indicated that the current opinions of the respondents on AVs might not remain true in the future considering the evolving nature and exposures of AV technology among pedestrians and bicyclists. The authors reccomnended that AV perception assessment studies should be conducted periodically to gather more accurate understanding of AV perceptions at a particular timeline.

Overall, this literature review has identified a critical gap in research that studies the influence of different factors on the safety perceptions of pedestrians and bicyclists who have had real-world road sharing experiences with AVs. Furthermore, the literature has identified a niche in assessing the differences in pedestrians' and bicyclists' perceptions of AVs over time. To address these gaps, our research investigated the influence of different factors on AV road sharing-related safety perceptions using pooled 2017 and 2019 BikePGH survey data gathered from Pittsburgh residents who had high AV exposures. These data have allowed us to analyze the differences in safety perceptions among pedestrians and bicyclists over time and investigate the changes of the influence of different factors on AV road sharing related safety perceptions over time.

3. Methods

3.1. Study data

Bike Pittsburgh (Bike PGH), an organization located in Pittsburgh, Pennsylvania, with a mission to reduce automobile dependency in the city, conducted two surveys in 2017 and 2019 to document the knowledge, experience, and perceptions of pedestrians and bicyclists regarding road sharing with AVs. Pittsburgh has been selected as 1 of the 10 testing grounds for AVs by USDOT, which provided pedestrians and bicyclists in Pittsburgh with reasonably high exposures to AVs since 2016 (USDOT, 2017). The Bike PGH surveys have documented pedestrians' and bicyclists' experiences, concerns, and expectations regarding road sharing with AVs in Pittsburgh. All closed-ended survey questions of the questionnaire and questions used in this study are provided in Table 1. In addition, the complete questionnaire can be accessed online using the link provided in this referenced resource WPRDC (n.d.).

BikePGH administered their surveys through email communication with BikePGH members and recruitment through the BikePGH website, social media sites, and news agencies. A total of 1,120 and 795 responses were gathered in 2017 and 2019, respectively. It is worth noting that the 2019 survey was not a follow-up survey of 2017 and did not necessarily have the same survey participants as the 2017 survey. Nevertheless, as BikePGH administered both surveys among its members, some survey participants might

Table 1
Survey Questions in 2017 and 2019 BikePGH Surveys.

Questions	Response Categories	Questions Used
To what extent have you been paying attention to the subject of AVs in the news?	Not at all, to little extent, to some extent, to a moderate extent, to large extent	✓
How familiar are you with the technology behind AVs?	Not familiar at all, somewhat familiar, mostly familiar, extremely familiar	✓
Have you shared the road with an AV while riding your bicycle on the streets of Pittsburgh?	Yes, no, not sure	✓
Have you shared the road with an AV while walking or using a mobility device in Pittsburgh?	Yes, no, not sure	✓
On a typical day, how safe do you feel sharing the road with human driven vehicles?	Assessed on a scale of 1 to 5 where 1 being very unsafe and 5 being very safe A "no experience" category added in the 2017 survey	✓
On a typical day, how safe do you feel sharing the road with AVs?	Assessed on a scale of 1 to 5 where 1 being very unsafe and 5 being very safe A "no experience" category added in the 2017 survey	✓
What effect do you think that AVs will have on traffic injuries and fatalities?	*2019 survey*: significantly worse, slightly worse, no effect, slightly better, significantly better *2017 survey*: yes, no, may be	✓
What do you think about the use of Pittsburgh's public streets as a proving ground for Autonomous Vehicles?	Disapprove, somewhat disapprove, neutral, somewhat approve, approve	✓
On City of Pittsburgh public streets, should AV speeds be capped when operating in "autonomous mode"?	Yes, no, not sure	✓
On City of Pittsburgh public streets, should AVs have two full-time employees (pilot and co-pilot) at all times? (Included in 2019 only)	Yes, no, not sure	×
On City of Pittsburgh public streets, do you think that AVs should operate in "manual mode" while in high-risk areas (e.g., active school zone)?	Yes, no, not sure	✓
On City of Pittsburgh public streets, should AV companies be required to share some non-personal data (e.g., number of trips, pickup/drop off locations, number of miles driven) with the proper authorities (e.g., Department of Mobility, PennDOT, Public Safety)?	Yes, no, not sure	✓
On City of Pittsburgh public streets, should AV companies be required to disclose information and data as to the limitations, capabilities, and real-world performance of their cars with the proper authorities? (Included in 2019 only)	Yes, no, not sure	×
On City of Pittsburgh public streets, should AV companies be required to report all safety-related incidents with the proper authorities, even if a police report isn't required? (Included in 2019 only)	Yes, no, not sure	×
On public streets, do you think that a regulatory authority should come up with regulations regarding how AVs are tested? (Included in 2017 only)	Yes, no, not sure	×
In March of 2018, an AV struck and killed Elaine Herzberg, a pedestrian, in Tempe, AZ. As a pedestrian and/or bicyclist, how did this event and its outcome change your opinion about sharing the road with AVs? (Included in 2019 only)	Significantly more negative opinion, somewhat more negative opinion, no change, somewhat more positive opinion, significantly more negative opinion	✓
What is your age? (Included in 2019 only)	18–24, 25–34, 35–44, 45–54, 55–64, 65+	✓
Are you currently an active member of BikePGH?	Yes, no	×
Is this an advocacy issue that BikePGH should dedicate resources to? (Included in 2017 only)	Strongly disagree, disagree, neutral, agree, strongly agree	×
What do you think BikePGH's position on AVs should be? (Included in 2017 only)	No opinion, actively oppose, neither support nor oppose, actively oppose	×
Do you (or someone in your household) own an automobile? (Included in 2019 only)	Yes, no	✓
Do you own a smartphone? (Included in 2019 only)	Yes, no	×
Please mention the Zipcode of your living area	ZipCode	✓

respond to both surveys. However, the extent of overlap of survey respondents in the two surveys was not documented. Notwithstanding this data limitation, this study provides an understanding of the relationships between vulnerable roadway users' AV safety perceptions with their technology familiarity, attitudes, and other characteristics, as well as an understanding of how these relationships might differ between Pittsburgh residents in 2017 and 2019. In addition, both Bike PGH surveys did not collect much information on the socioeconomic and demographic characteristics of the survey participants, which limits the assessment of the representativeness of the collected sample. In the 2019 survey, BikePGH gathered data on the age of the survey participants. The comparison of the distribution of the age of the respondents in the 2019 BikePGH survey and that of the residents of the city of Pittsburgh using data from the American Community Survey 2019 revealed that the 2019 BikePGH survey closely represents the older age groups of 55–64 and 65+ (see Table 2). However, the middle age groups (i.e., 35–44 and 45–54) are overrepresented, while the younger age groups (i.e., 18–24 and 25–34) are underrepresented in the sample. Nevertheless, the target population of this survey was adult pedestrians and bicyclists residing in Pittsburgh. Detailed information on walking and bicycle mode usage in Pittsburgh by age is not available, and therefore, the true representativeness of the sample cannot be accurately inferred.

3.2. Analysis method

3.2.1. Statistical testing

This study applied statistical testing to investigate safety perception differences among pedestrians and bicyclists based on their characteristics, experiences, and attitudes. The survey measured the safety perceptions of pedestrians and bicyclists using an ordinal scale (i.e., a 5-point Likert scale). As no cumulative or average of multiple scales are used, interval scale properties cannot be achieved. Non-parametric statistical methods are more appropriate for analyzing ordinal data. Safety perceptions of pedestrians and bicyclists by different factors were analyzed using the Wilcoxon Rank Sum and Kruskal Wallis test, which are non-parametric versions of the standardized t-test and ANOVA test, respectively. Wilcoxon Rank Sum test was used to compare the differences between two groups identified based on a factor (e.g., shared or did not share roadways with AVs). The Kruskal-Wallis test was used to compare the differences among three or more groups identified based on a factor (e.g., three different age groups of respondents). In addition, statistical testing was performed to compare the difference in responses between the 2017 and the 2019 surveys. Wilcoxon Rank Sum tests were used to compare ordered categorical responses (e.g., responses to the survey questions on paying attention to AV news, safety perception on sharing roads with human-driven vehicles, safety perception on sharing roads with AVs, approval of AV testing in public roadways). Chi-squared tests were performed to compare unordered categorical responses (e.g., responses to the survey questions on sharing the road with AV as a pedestrian, sharing the road with AV as a bicyclist).

Table 2
Summary Age Statistics of the Sample of Pittsburgh, PA.

Age Group	2019 Bike PGH Survey (%)	American Community Survey (%) *	Test of proportion (p-value)
18–24	4.3%	16.3%	<0.001
25–34	26.1%	29.2%	0.05
35–44	22.4%	14.1%	<0.001
45–54	16.4%	13.5%	0.02
55–64	18.4%	16.3%	0.11
65+	12.5%	10.7%	0.12

* Retrieved from the American Community Survey Data, 2019, for the city of Pittsburgh.

3.2.2. Safety perception modeling

An ordered probit model was estimated to identify the factors influencing vulnerable roadway users' safety perceptions of AVs using pooled data from 2017 and 2019 surveys. Considering the ordered nature of the safety perception data, the ordered probit model was an appropriate model that could be used without losing any information compared to a standard or nested multinomial probit model (Pyrialakou et al., 2020). The consideration of ordinal variable rather than nominal has several advantages: simplicity in interpretations, more robust and flexible model, and resemblance with ordinary regression analysis (Zheng et al., 2014). Ordered probability models are generally derived by defining an unobserved variable, Z. The unobserved variable Z enables modeling of the ordinal ranking of data and is specified with a linear function:

$$z = \beta X + \epsilon \tag{1}$$

Where, the vector of variables X represents the discrete ordering of n observations, β is a vector of estimated parameters, and ϵ indicates random disturbance. Based on the equation, the observed ordinal data, y for each observation, can be defined as:

y = 1 if z $\leq \mu_0$

$$y = 2 if \mu_0 \leq z \leq \mu_1 \tag{2}$$

y = I if z.$\geq \mu_{I-1}$

Where, I is the highest integer ordered response, μ are the estimated parameters (thresholds) that define y. The parameters correspond to the integer ordering of the dependent variable. It was assumed that ϵ was distributed randomly across observations to estimate the probability of specific ordered responses. The ordered selection probabilities follow the following expressions, where φ is the cumulative normal distribution.

$$P(y = 1) = \varphi(-\beta X)$$

$$P(y = 2) = \varphi(\mu_1 - \beta X) - \varphi(-\beta X) \tag{3}$$

$$P(y = I) = 1 - \varphi(\mu_{I-1} - \beta X)$$

The variables "safety perceptions on human-driven vehicles" and "expectations of AV to reduce traffic injuries and fatalities" could potentially be endogenous to the dependent variables. Therefore, both variables were modeled using binary probit models with exogenous variables to address the potential endogeneity. The resulting probabilities were then used as inputs to the estimated ordered probit model. To account for the unobserved factors, random parameters were estimated in the model. The inclusion of random parameters facilitates the interpretation of heterogeneity. Random parameters in ordered probit model were evaluated by simulated maximum likelihood estimation using halton draws. 200 halton draws were used, which ensure accurate estimation of the parameters and maintain efficient calculation (Bhat 2001; Gkritza & Mannering 2008).

4. Analysis and results

The descriptive statistics of the survey responses to the closed-ended survey questions are provided in Table 3. In addition, the p-values of the statistical tests that compared the 2017 and 2019 survey responses are provided.

Table 3
Summary of Descriptive Statistics-2017 and 2019 Surveys.

Factor	Response	Frequency (percentage) Survey 1: 2017	Frequency (percentage) Survey 2: 2019	p-value
Age *(n_2 = 788)*	18–24		34 (4.3%)	
	25–34		205 (26.0%)	
	35–44	N/A	176 (22.3%)	
	45–54		129 (16.4%)	
	55–64		145 (18.4%	
	65+		98 (12.4%)	
Automobile Ownership *(n_2 = 792)*	Yes	N/A	748 (94.4%)	
	No		44 (5.6%)	
Attention to AV News *(n_1 = 1120, n_2 = 794)*	None at all	15 (1.3%)	8 (1.0%)	
	To little extent	102 (9.1%)	43 (5.4%)	
	To some extent	337 (30.1%)	162 (20.4%)	<0.001***
	To a moderate extent	371 (33.1%)	293 (36.9%)	
	To a large extent	295 (26.3%)	288 (36.3%)	
AV Technology Familiarity *(n_1 = 1120, n_2 = 794)*	Not familiar at all	71 (6.3%)	69 (8.7%)	
	Mostly unfamiliar	236 (21.1%)	N/A	
	Somewhat familiar	480 (42.9%)	306 (38.5%)	
	Mostly familiar	226 (20.2%)	256 (32.2%)	
	Extremely familiar	107 (9.6%)	163 (20.5%)	
Sharing Road as Pedestrian *(n_1 = 1120, n_2 = 793)*	Yes	508 (45.4%)	481 (60.6%)	
	No	498 (44.5%)	243 (30.6%)	<0.001***
	Not sure	114 (10.2%)	69 (8.7%)	
Sharing Road as Bicyclist *(n_1 = 1120, n_2 = 792)*	Yes	409 (36.5%)	422 (53.3%)	
	No	602 (53.8%)	254 (32.1%)	<0.001***
	Not sure	109 (9.7%)	116 (14.6%)	
Safety Perception of Human-Driven Vehicles *(n_1 = 1120, n_2 = 792)*	No experience[a]	8 (0.7%)	N/A	<0.001***
	1-very unsafe	59 (5.3%)	69 (8.7%)	
	2	320 (28.5%)	231 (29.2%)	
	3	454 (40.5%)	356 (44.9%)	
	4	240 (21.4%)	117 (14.8%)	
	5-very safe	39 (3.5%)	19 (2.4%)	
Expectation on AV Safety Improvement Potential *(n_2 = 788)*	Significantly worse		39 (4.9%)	
	Slightly worse		76 (9.6%	
	No effect	N/A	100 (12.7%)	
	Slightly better		270 (34.3%	
	Significantly better		303 (38.5%)	
Approval of AV Testing in Public Roadways *(n_1 = 1120, n_2 = 792)*	Disapprove	88 (7.9%)	66 (8.3%)	
	Somewhat disapprove	99 (8.8%)	85 (10.7%)	
	Neutral	146 (13.0%)	92 (11.6%)	0.25
	Somewhat approve	227 (20.3%)	168 (21.2%)	
	Approve	560 (50%)	381 (48.1%)	
	No experience[a]	117 (10.4%)	N/A	
Safety Perception of AVs *(n_1 = 1120, n_2 = 787)*	1-very unsafe	59 (5.3%)	57 (7.2%)	
	2	106 (9.5%)	68 (8.6%)	
	3	261 (23.3%)	179 (22.7%)	0.003[a]**
	4	370 (33.0%)	249 (31.6%)	
	5 -very safe	207 (18.5%)	234 (29.7%)	
Capping AV Speed Limit *(n_1 = 1120, n_2 = 792)*	Yes	572 (51.1)	303 (38.3)	<0.001***
	No	338 (30.2)	269 (34.0)	
	Not sure	210 (18.8)	220 (27.8)	
Manual Mode in High-risk Zones *(n_1 = 1003, n_2 = 793)*	Yes	279 (24.9)	396 (49.9)	<0.001***
	No	527 (47.1)	208 (26.2)	
	Not sure	314 (28.0)	189 (23.8)	
Sharing Non-personal Data *(n_1 = 1003, n_2 = 793)*	Yes	802 (71.6)	591 (74.5)	0.12
	No	139 (12.4)	102 (12.9)	
	Not sure	179 (16.0)	100 (12.6)	
Influence of Pedestrian and Bicyclist involved AV Accident *(n_2 = 792)*	Negative change		292 (36.9%)	
	No change	N/A	478 (60.4%)	
	Positive change		22 (2.8%)	

Wilcoxon Rank Sum test (for ordered categorical response on - attention to AV news, safety perception of human-driven vehicles, safety perception on sharing roads with AVs, approval of AV testing in public roadways) and chi-square test (for unordered categorical response on– sharing the road as a pedestrian, sharing the road as a bicyclist, capping AV speed limit, manual mode in high-risk zones, sharing non-personal data) showed significant difference in responses between 2017 and 2019 at the following level: * = $p \leq 0.10$, ** = $p \leq 0.05$, ***= $p \leq 0.001$.
n_1, n_2 are the number of respondents in 2017 and 2019 surveys, respectively.
N/A- Data was not collected.
[a] Test excludes the "no experience" response of the 2017 survey.

4.1. Comparison of 2017 and 2019 survey responses

The major difference observed among the respondents in the 2017 and the 2019 surveys was their exposure to AVs, but there were statistically significant differences in most of the other common questions administered. Nearly 45% and 37% of the respondents shared the road with AVs as pedestrians and bicyclists in the 2017 survey, respectively, and 61% and 53% of the respondents shared the road with AVs as pedestrians and bicyclists in the 2019 survey, respectively (Table 3). A potential reason for this higher percentage is the longer exposure of AV operations in 2019 than in 2017 since the beginning of the pilot AV operations in Pittsburgh. Chi-squared tests indicated that both differences are statistically significant. It is noted here that both surveys did not ask for the exact timeline or duration of the respondents' road sharing experiences with AVs. Thus, it is expected that respondents who participated in both surveys and had an AV road sharing experience prior to 2017 would also report this experience in the 2019 survey, even if they had not had another experience between 2017 and 2019. Pedestrians and bicyclists have also become more familiar with AV technology and paid more attention to AV on the news over time. Nearly 60% of the respondents in the 2017 survey paid attention to AV on the news to a moderate or large extent, where nearly 73% of the respondents in the 2019 survey paid the same level of attention. The difference is also statistically significant.

Safety perceptions while sharing roads with AVs became more positive over time. In the 2017 survey, nearly 51% of the respondents rated safety in sharing roads with AVs highly (i.e., 4 or 5). In the 2019 survey, 60% of the respondents expressed similar safety perceptions. The difference in AV road sharing-related safety perceptions is statistically significant between the two surveys. In contrast, safety perceptions of sharing roadways with human-driven vehicles decreased. In 2017, 25% of the respondents perceived themselves as highly safe while sharing roadways with human-driven vehicles, which was reduced to 17% among the respondents in 2019 survey. In both surveys, nearly 35% of respondents perceived road sharing with human-driven vehicles as less safe (i.e., rated 1 or 2 on a scale of 1 to 5), which was higher compared to their safety perceptions while sharing roadways with AVs (i.e., nearly 15% of respondents perceived AV as less safe in both surveys). This finding is in line with the study of Hulse et al. (2018). Over time, respondents showed a higher support toward capping AV speed limit, but a less support toward driving AVs at manual mode in high-risk zones (e.g., near schools). Respondents highly supported personal data sharing with proper authorities in both surveys. Additional findings and discussions on the differences in AV safety perceptions among the vulnerable roadway users over time are presented in the following subsections.

4.2. Difference in safety perceptions of AVs among pedestrians and bicyclists across different characteristics, experiences, and attitudes

Survey respondents can be characterized by their demographics and socioeconomic characteristics, AV exposures, perceptions of human-driven vehicles, their expectations on AV safety, and opinions on AV testing and AV regulations. Statistical testings were performed in terms of the pedestrians' and bicyclists' characteristics, experiences, and attitudes assessed in the 2017 and the 2019 surveys (questionnaires presented in Table 1) to investigate the influence of these factors on AV safety perceptions in two survey time periods.Survey participants were grouped to maintain at least 10% responses in all categories. A detailed description of the combined categories can be found in the Ap***pendix, Tab**le A1. Details of testing results for 2017 and 2019 surveys are presented in Table 4.

As mentioned earlier, the BikePGH surveys collected limited information on the respondents' demographics and socioeconomic characteristics (i.e., only age and automobile ownership information were collected and only in the 2019 survey). The 2019 survey analysis indicated that younger respondents had higher safety perceptions of road sharing with AVs than older respondents. According to the survey responses, household automobile ownership was positively associated with AV safety perceptions. Respondents with higher AV technology familiarity and those who paid more attention to the AV news had higher safety perceptions of road sharing with AVs. In addition, active road sharing experiences were associated with enhanced perceived safety. For example, in the 2019 survey, 70% of the respondents who shared roadways with AVs as bicyclists expressed high perceived safety in road sharing with AVs. In contrast, among the respondents who did not share roadways with AVs as a bicyclist, 53% perceived high safety in road sharing with AVs.

In addition to the associations between the various factors and perceived safety, Table 4 summarizes the differences between the 2017 and the 2019 surveys. When the differences in perceptions are explored across groups, it can be seen that safety perceptions differed over time within some groups. The 2019 respondents with road sharing experiences had higher safety perceptions compared to the 2017 respondents with road sharing experiences. The perceptions of the respondents in all three levels of safety perceptions on human-driven vehicles were statistically different between 2017 and 2019. The 2019 respondents who felt unsafe/neutral while sharing roadways with human-driven vehicles, had higher perceptions of safety than the 2017 respondents, while the opposite pattern was found among the respondents who felt safe while sharing roadways with human-driven vehicles. There was no evidence that the safety perceptions of the 2017 and 2019 respondents with worse expectations on AV safety improvement potential were statistically different. On the other hand, the 2019 respondents with neutral/better expectations on AV safety improvement potential perceived AVs as safer than the 2017 respondents. Finally, both groups of respondents in 2019 with less strict and stricter attitudes towards AV regulations had higher safety perceptions than the 2017 respondents.

For almost all factors, similar statistical significance levels were found while testing the differences in AV safety perceptions among groups within a factor in 2017 and 2019 surveys. It can be inferred that despite the differences in perceptions between 2017 and 2019, the influences of different factors had a similar effect on AV road sharing-related safety perceptions in both surveys. For example, in both 2017 and 2019, people who paid more attention to AV-related news had, on average, statistically higher safety perceptions compared to those who did not.

4.3. Modeling safety perceptions of pedestrians and bicyclists regarding road sharing with AVs

Table 5 presents the ordered probit model estimation results and the marginal effects of the independent variables using the combined 2017 and 2019 survey data. The pooled dataset was used to ensure an adequate sample size for reliable parameter estimation. The selection of independent variables in the model was guided by previously performed statistical testing, past studies, and the statistical significance of the variables in the model. Several interaction variables were explored. An interaction variable consisting of a binary variable (i.e., 1-data collected in the 2019 survey and 0-data collected in the 2017 survey) and the influence of the recent pedestrian /bicyclist involved AV accident (i.e., 1-negative change in opinion, 2- no change or positive change in opinion) was found significant in the final model. This interaction variable captures the impact of the 2018 pedestrian/bicyclist-

Table 4
Differences of Safety Perceptions of Road Sharing with AVs Among Pedestrians and Bicyclists Across Different Characteristics, Experiences, and Attitudes.

Factor	2017 survey Respondents rated AV safety highly (i.e., rated 4 or 5) (%)	Statistical test p-value of changing perception across groups	2019 survey Respondents rated AV safety highly (i.e., rated 4 or 5) (%)	Statistical test p-value of changing perception across groups	Statistical test p-value when comparing 2017 and 2019 survey
Age					
18–34 years old *($n_2 = 238$)*			65.55		
35–54 years old *($n_2 = 302$)*	N/A	N/A	61.59	0.003**	
55 + years old *($n_2 = 239$)*			57.32		
Household Automobile Ownership					
Yes *($n_2 = 740$)*	N/A	N/A	62.3	0.02**	
No *($n_2 = 44$)*			47.73		
Attention to AV News					
Less ($n_1 = 379$, $n_2 = 210$)	42.48	<0.001***	43.81	<0.001***	0.85
More ($n_1 = 613$, $n_2 = 576$)	66.56		67.71		0.95
AV Technology Familiarity					
Less familiar ($n_1 = 682$, $n_2 = 371$)	51.17	<0.001***	43.81	<0.001***	0.23
More familiar ($n_1 = 309$, $n_2 = 416$)	70.87		67.71		0.11
Sharing Road as Pedestrian					
Yes ($n_1 = 491$, $n_2 = 481$)	64.35	<0.001***	67.57	<0.001***	0.009**
No ($n_1 = 401$, $n_2 = 238$)	50.62		54.62		0.24
Sharing Road as Bicyclist					
Yes ($n_1 = 403$, $n_2 = 421$)	64.76	<0.001***	70.31	<0.001***	0.003**
No ($n_1 = 493$, $n_2 = 249$)	52.13		53.01		0.16
Safety Perception of Human driven vehicles					
Unsafe ($n_1 = 335$, $n_2 = 298$)	53.73	<0.001***	63.42	0.03**	<0.001***
Neutral ($n_1 = 414$, $n_2 = 352$)	51.45		60.51		0.005**
Safe ($n_1 = 243$, $n_2 = 135$)	72.43		60		0.06**
Expectation on AV Safety Improvement Potential					
Worse expectation ($n_1 = 65$, $n_2 = 112$)	9.23	<0.001***	4.46	<0.001***	0.46
Neutral ($n_1 = 191$, $n_2 = 99$)	28.79		32.32		0.01**
Better expectation ($n_1 = 665$, $n_2 = 571$)	74.59		77.58		0.003**
Attitudes towards AV Regulations					
Less strict attitude ($n_1 = 530$, $n_2 = 371$)	73.39	<0.001***	80.05	<0.001***	<0.001***
Stricter attitude ($n_1 = 473$, $n_2 = 416$)	39.75		44.71		0.05**

Wilcoxon Rank Sum test (for household automobile ownership, attention to AV news, AV technology familiarity, sharing road as pedestrian, sharing road as bicyclist, attitudes towards AV regulations) and Kruskal Wallis tests (for age, safety perception of human-driven vehicles, expectation on AV safety improvement potential) showed significant difference in safety perceptions on the road sharing with AVs at the following levels: **= $p \leq 0.05$; ***= $p \leq 0.001$.
n_1, n_2 are the number of respondents of 2017 and 2019 surveys, respectively.

Table 5
Ordered Probit Model Estimation Results to Model Pedestrians' and Bicyclists' Road Sharing Perceptions with AVs and Marginal Effects of Explanatory Variables.

Variable (Base category)	Estimated parameter (p value)	Marginal effects (p value)		
		Unsafe	Neither safe nor unsafe	Safe
Constant	−0.792(0.011)			
AV Technology Familiarity (Less)				
More	0.236 (0.025)	−0.048 (0.021)	−0.044(0.027)	0.092(0.023)
Sharing Road as Bicyclist (No)				
Yes	0.343 (<0.001)	−0.071 (<0.001)	−0.063 (<0.001)	0.134 (<0.001)
Sharing Road as Pedestrian (No)				
Yes	0.303 (<0.001)	−0.064 (<0.001)	−0.055 (<0.001)	0.119 (<0.001)
Safety Perception of Human Driven vehicles (Not safe)[a]				
Safe	1.566 (0.072)	−0.324 (0.072)	−0.290 (0.074)	0.614 (0.072)
Expectation on AV Safety Improvement Potential (Neutral or worse expectations) [a]				
Better expectation	1.451 (0.012)	−0.300 (0.013)	−0.269 (0.013)	0.569 (0.012)
Approval of AV Testing in Public Roadways (Neutral)				
Disapprove	−0.984 (<0.001)	0.294 (0.005)	0. 074 (<0.001)	−0.368 (<0.001)
Somewhat disapprove	−0.155 (0.394)	0.034 (0.425)	0.027 (0.357)	−0.061 (0.397)
Somewhat approve	0.043 (0.803)	−0.009 (0.800)	−0.008 (0.805)	0.016 (0.802)
Approve	0.478 (0.043)	−0.100 (0.046)	−0.086 (0.035)	0.186 (0.039)
Attitudes toward AV Regulation (Less strict attitude)				
Stricter attitude	−0.277 (<0.001)	0.057 (<0.001)	0.051 (<0.001)	−0.108 (<0.001)
Influence of Pedestrian and Bicyclist involved AV Accident (year 2017)				
Negative change in opinion	0.059 (0.548)	−0.012 (0.544)	−0.011 (0.561)	0.023 (0.552)
No change or positive change in opinion	0.479 (<0.001)	−0.086 (<0.001)	−0.094 (<0.001)	0.181 (<0.001)
Threshold	0.959(<0.001)			
Pseudo R-squared	0.26			
Log likelihood function	−1142.47			
Restricted log likelihood function	−1547.09			
Number of observations	1577			

All parameters were resulted as fixed parameters.
[a] predicted probability by calculating an estimated binary probit model.

involved AV accident on the road sharing safety perception of AVs in 2019 compared to the safety perceptions assessed in the 2017 survey.

In the final model, safety perceptions of road sharing with AVs were found associated with: *(i)* AV exposures, *(ii)* safety perception of human-driven vehicles, *(iii)* expectation on AV safety improvement potential, *(iv)* approval of AV testing in public roadways, *(v)* attitudes towards AV regulations, and *(vi)* influence of pedestrians and bicyclists involved AV accident.

(i) AV exposures

The results of the model indicate that pedestrians and bicyclists who were more familiar (mostly or extremely familiar) with the technology behind AVs were more likely to have higher safety perceptions. Specifically, more familiar respondents were 9.2% more likely to be perceived safe, and 4.8% less likely to be perceived unsafe while sharing roadways with AVs. Similarly, respondents who shared roadways with AVs were more likely to have higher safety perceptions of AVs. Respondents who shared roadways with AVs as bicyclists were 13.4% more likely to be perceived safe and 7.1% less likely to be perceived unsafe, whereas those who shared roadways as pedestrians were 11.9% more likely to be perceived safe and 6.4% less likely to be perceived unsafe.

(ii) Perceptions on human-driven vehicles

Higher safety perceptions regarding road sharing with human-driven vehicles were associated with higher safety perceptions of sharing roadways with AVs. Specifically, with the increase of safety perceptions of human-driven vehicles, 61.4% of respondents were more likely to be perceived safe, and 32.4% were less likely to be perceived unsafe in sharing the road with AVs. Although a positive association between safety perceptions of human-driven vehicles and AVs was found, a negative association could be observed in the future if the observed trend between 2017 and 2019 strengthens.

(iii) Expectations on AV safety

Expectations on AV safety to reduce traffic injuries and fatalities were positively associated with pedestrians' and bicyclists' AV safety perceptions. Respondents with higher AV safety expectations were 56.9% more likely to be perceived safe and 30% less likely to be perceived unsafe.

(iv) Opinions on AV testing on public roadways

Compared to the respondents who took a neutral stance on approving AV testing in public roadways, respondents who "somewhat approved" or "approved" AV testing were more likely to have higher safety perceptions. Contrary, respondents who "somewhat disapproved" or "disapproved" AV testing were more likely to have lower safety perceptions. The marginal effect of this variable indicates that respondents who "approved" AV testing were 18.6% more likely to be perceived safe and 10% less likely to be perceived unsafe, whereas the respondents who "disapproved" AV testing were 36.8% less likely to be perceived safe and 29.4% more likely to be perceived unsafe compared to the respondents who took a neutral stance.

(v) Attitudes on AV regulations

Respondents with a stricter attitude to AV regulations were more likely to have lower safety perceptions. For individuals with stricter attitudes, the probability of feeling safe while sharing the road with AVs was 10.8% lower, and the probability of feeling unsafe was 5.7% higher.

(vi) Influence of pedestrians and bicyclists-involved AV accidents

In 2018, an Uber AV-involved crash resulted in the death of Elaine Herzberg who was walking with a bicycle before the crash in Tempe, Arizona. The questionnaire of 2019 survey asked about the extent that this crash influenced the respondents' opinions on road sharing with AVs. Compared to the survey respondents of 2017, in the 2019 survey, respondents whose opinion did not worsen about AVs following the fatal crash were more likely to have higher safety perceptions of AVs. These respondents were 18.1% more likely to perceive themselves safe and 8.6% less likely to perceive themselves unsafe than the survey respondents of 2017.

5. Discussion and policy implications

Pedestrians and bicyclists are among the most vulnerable roadway users who might share a road with AVs. To deploy AVs at public roadways on a large scale in the future and ensure acceptance of AVs, it is necessary to improve safety perceptions among pedestrians and bicyclists in terms of sharing roadways with AVs. In this study, the AV safety perceptions and the influence of different factors on AV safety perceptions were analyzed over two survey timelines (i.e., 2017 and 2019). As literature has concluded, investigating the changes in AV safety perceptions over time is essential because the public receives more information about AVs and becomes more aware of AV technology capabilities over time. For example, Saeed et al. (2020) highlighted the public's changing perceptions of AV technology with the increased operation of AVs in public roadways over time. The authors discussed that the public perceptions of AV will become more stable over time, and studies should be conducted periodically to understand any deviations from previously identified trends. This study, thus, provides valuable insights regarding the potential differences in safety perceptions and the influences of different factors on safety perceptions over time.

In both Bike PGH surveys, it was found that road sharing experiences among the respondents as pedestrians and bicyclists increased their safety perceptions of sharing roadways with AVs. Among the respondents who shared roadways with AVs as a pedestrian or a bicyclist, approximately 66% of them had high safety perceptions, whereas among the respondents who did not, about 50% of them had high safety perceptions. Thereby, road sharing experiences with AVs as pedestrians or bicyclists can potentially increase AV road sharing-related safety perceptions. Higher safety perceptions with higher AV exposures are generally anticipated, as previous studies concluded that knowledge on AVs had a positive influence on AV safety perceptions (Penmetsa et al., 2019; Pyrialakou et al., 2020; Lee et al. 2017). Higher AV exposures (i.e., knowledge about AVs or sharing roads with AVs considered in this study) potentially helped increase AV technology awareness among the respondents and improve safety perceptions regarding road sharing with AVs. Previous studies found that increased awareness of AVs among people contributed to high safety perceptions (Pyrialakou et al., 2020). These findings suggest that a similar conclusion is true for pedestrians and bicyclists. The current findings corroborate previous studies implications (see, for example, Liu & Xu, 2020) and propose that policymakers and technology developers could enable projects to operate test AVs in major walking and bicycle used locations so that pedestrians and bicyclists could get practical road sharing experiences with AVs, which in turn would improve their safety perceptions of AVs.

Furthermore, a positive association between the safety expectations from AVs and AV safety perceptions was found from the analysis. Previous studies also reported that skeptical people (i.e., skeptical of new ideas and emerging technologies) felt that AVs are less safe (Pyrialakou et al., 2020). Along the same lines, Das et al. (2020) reported that safety expectations of pedestrians and bicyclists could be increased by enabling their interactions with AVs.

In recent years, many AV technology developers began testing on public roadways. Therefore, the approval of vulnerable roadway users to let AV testing on public roadways is necessary. Although safety perceptions about sharing roads with AVs seem to have improved over time, people's opinions on using Pittsburgh public roads for AV testing have not differed significantly. While most respondents showed approval of AV testing on public roads, nearly 30% of the respondents in both surveys either disapproved or took a neutral stance on allowing the Pittsburgh public roads as the AV proving ground. This finding is in line with Hulse et al. (2018). Model results indicated that higher approval of AV testing in public roadways was positively associated with AV safety perceptions and vice versa, which is in line with the findings of Grush and Niles (2018) and Henaghan (2018). However, although the model results in this research indicated that strong approval or disapproval of AVs testing was significantly associated with higher or lower perceptions of safety, respectively, there is no evidence that partial approval or disapproval influenced AV safety perceptions significantly. Stricter attitude on AV regulations was associated with lower AV safety perceptions. Stricter attitude toward AV regulations among pedestrians and bicyclists could be softened by finding ways to spread enthusiasm about AV technology and easing their AV-related anxiety. For example, Nair and Bhat (2021) suggested campaigns to increase enthusiasm for AV technology, reduce anxiety, and enhance tech-savviness. The study proposed that such campaigns should target older individuals, individuals with low education levels, low incomes, the unemployed, and people who strongly support AV regulations. Measures like a targeted campaign have the potential to reduce stricter attitudes toward AV regulations and improve safety perceptions regarding road sharing with AVs.

Following the AV-involved accident in Arizona, the AV road sharing related safety perceptions of a noticeable portion of the pedestrians and bicyclists surveyed were negatively affected. This result is in line with the findings of past studies. According to Saeed (2019), AV-involved accidents have contributed to damaging safety perception and trust of traditional automobile users and other roadway users, in addition to the users of AVs. News media usually portrait AVs as uncertain and unreliable mode of transportation following an AV accident, which could negatively impact the perceptions of pedestrians and bicyclists (Saeed et al., 2020). Policymakers and technology developers could develop effective educational tools/resources as well as initiate demonstration projects to inform the pedestrians and bicyclists about AV technology reliability and improve their safety perceptions.

Finally, turning to the socioeconomic and demographic characteristics collected, the 2019 survey analysis revealed that younger respondents have higher safety perceptions in terms of road sharing with AVs than older respondents. This finding is in line with previous studies concluding that younger age groups are less concerned with AV safety (Hulse et al., 2018; Pyrialakou et al., 2020; Charness et al., 2018; AAA, 2017; Schoettle & Sivak, 2014; Mody et al., 2020) and more likely to be AV early adopters. However, Madigan et al. (2016) indicated cultural distinctions as an important factor influencing the perception of AVs in terms of age. The authors reported higher AV acceptance among the younger population of Greece but the older population of France and Switzerland. In addition, this study found that household automobile ownership has a positive association with AV safety perceptions. Pyrialakou et al. (2020) reported a similar finding in their study. They found that increased ownership of vehicles (i.e., three or more) was associated with higher safety perceptions towards AVs.

6. Conclusions

This study investigated the opinions of vulnerable roadway users (i.e., pedestrians and bicyclists) regarding their perceived safety of sharing roadways with AVs using the BikePGH survey data. Over time, pedestrians and bicyclists became more familiar with AVs, paid more attention to AV-related news, and shared roadways more with AVs. The estimated ordered probit model revealed that pedestrians and bicyclists with higher exposures to AVs had higher perceived safety on sharing roadways with AVs. Approval and disapproval of AV testing in public streets were associated with higher and lower safety perceptions, respectively, where partial approval and disapproval did not significantly influence AV safety perceptions. 2019 survey respondents whose opinion of AV safety did not worsen following the fatal crash in Arizona were more likely to have higher safety perceptions compared to the survey respondents of 2017. The findings of this study could be translated into policy decisions and interventions to improve pedestrians' and bicyclists' safety perceptions regarding sharing the road with AVs.

This study has some limitations worth addressing. First, the BikePGH survey samples of 2017 and 2019 surveys were not the same. Although there might be some overlap between the two samples (as BikePGH members participated in both surveys) and similar distribution of survey samples were found by Zipcode level, the change in opinions over time did not necessarily represent the change of the perceptions of the same respondents. Future research should conduct longitudinal studies (i.e., assess perceptions of the same participants over time) to gather more accurate information on the changes of AV safety perceptions and the influence of different factors on the AV safety perceptions over time. Secondly, while the survey was administered on-line, information regarding response source type (e.g., social media, news ad, email), and response rates mostly were not available for this reserach. Information on total responses by different sources and response rates could add value to the survey findings and understanding of the survey sample. Thirdly, the surveys did not collect information on many socioeconomic and demographic characteristics of the survey participants. The absence of such information brings three limitations. The representativeness of the sample cannot be easily assessed, the sampling weights cannot be obtained and used to balance the dataset and ensure the representations of the population, and the data do not allow the exploration of differences among different population groups. The influences of diverse socioeconomic and demographic characteristics on AV road sharing-related safety perceptions should be assessed in future research. Forthly and along the same lines, the surveys were conducted in Pittsburgh, Pennsylvania. Thereby, the findings of this study might not be transferable to other cities/states or other countries due to differences in AV exposures, demographics, socioeconomic, transportation system, and travel behavior characteristics (Saeed et al., 2020; Saeed, 2019). Further, the the BikePGH data collection framework was not designed to ensure a sample representative of the population of Pittsburgh, as it followed non-probabilistic, convenience sampling methods. Although the analysis of the BikePGH surveys provides valuable insights on AV safety perceptions, future surveys should focus on designing a data collection framework that can facilitate the collection of a representative sample.

Finally, as past literature discussed, the current opinions of the respondents on AVs may not remain true in the future, as perceptions of the emerging technologies are likely to change with AV exposures (Saeed et al., 2020; Saeed, 2019). As mentioned in the discussion section, future studies should be conducted periodically to understand the preferences of pedestrians and bicyclists on AVs at different timelines and to assess future perception trends more accurately. Such studies could also expand the scope of this analysis and attempt to distinguish between correlational and causal relationships among the different factors and AV safety perceptions (Moody et al. 2020). Fifthly, BikePGH surveys were focused on assessing safety perceptions of pedestrian and bicyclists. Future studies could assess safety perceptions of other vulnerable roadway users (e.g., construction workers, motor cyclists, runners, skaters).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

See Table A1.

Table A.1
Description of Combined Categories.

Factor	Combined Category	Primary Categories
Attention to AV News	Less More	None at all, to little extent, to some extent To moderate extent, to large extent
AV Technology Familiarity	Less More	Not familiar at all, mostly unfamiliar, somewhat familiar Mostly familiar, extremely familiar
Safety Perceptions of Human Driven Vehicles	Unsafe Neutral Safe	Rated perception as "1″ or "2″ in a scale of 1 to 5 Rated perception as "3″ in a scale of 1 to 5 Rated perception as "4″ or "5″ in a scale of 1 to 5
Safety Perceptions of Avs	Unsafe Neutral Safe	Rated perception as "1″ or "2″ in a scale of 1 to 5 Rated perception as "3″ in a scale of 1 to 5 Rated perception as "4″ or "5″ in a scale of 1 to 5
Expectation on AV Safety Improvement Potential	Worse expectation	-"Significantly worse" and "slightly worse" response categories in 2019 survey -"No" response category in 2017 survey
	Neutral	-"No effect" response categories in 2019 survey -"May be" response category in 2017 survey
	Better expectation	-"Significantlly better" and "slightly better" response categories in 2019 survey –No response category in 2017 survey
Attitude towards AV regulations	Less strict attitude Stricter attitude	An index was formed to calculate sum of the responses to all three regulation related questions, which varied between 0 to 3. Index values "0″ and "1″ were categorized as less strict attitude, where "2″ and "3″ were categorized as stricter attitude towards AV regulations.

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