

What Can My Car Tell Me? Consumer Perceptions of Transparency in Self-Driving Vehicles

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Abstract—Fully autonomous or “self-driving” vehicles are emerging mobility technology with potential benefits over conventional motor vehicles. Proponents argue that the widespread adoption of autonomous vehicles may save countless lives and millions of dollars annually by minimizing the likelihood of deadly vehicle crashes. However, widespread adoption of automated-driving technologies is required to realize such benefits, which research suggests, may be undermined by consumer concerns about vehicle operation transparency. Further, there is insufficient research into consumer perceptions of an autonomous vehicle’s communication and information-sharing behavior, which may impact their likelihood of purchasing one. We conducted a study using a 63-question internet-based survey distributed in the United States to licensed drivers 18 years of age and older ($n=996$) to examine consumer perceptions of autonomous vehicles across accountability, communication, information sharing, and concerns. Our findings show that consumer perceptions of the four dimensions vary significantly across race, gender, and ability.

Index Terms—self-driving vehicles, human-machine interfaces, transparency, survey

I. INTRODUCTION

As automated vehicle technologies continue to advance, the potential benefits of this technology are becoming more broadly discussed. The most advanced of these technologies, SAE Level 5 fully automated or “self-driving” vehicles [1] (AVs), have been described as revolutionizing personal mobility by minimizing the role of arguably error-prone human drivers. By eliminating the need for a fatigued, distracted, or impaired human being to manipulate a vehicle’s manual controls, it is projected that deadly motor vehicle crashes may be reduced by as much as 90 percent [2], [3]. This drastic reduction in crashes will save lives and save millions of dollars in property damage and loss. Given that it is projected that consumers will first interact with automated vehicles via ridesharing platforms, like Uber and Lyft, it is further anticipated that the move towards automated vehicles will translate into fewer net vehicles on the road. Instead of purchasing a personal vehicle, consumers may share vehicles in automated fleets, a move towards a Transportation-as-a-Service (TaaS) model of vehicle use. The overall net reduction

in vehicles on the road may reduce climate change-related greenhouse gasses while also redesigning city centers and roadways.

While the benefits of vehicle automation are significant, consumer adoption is critical for these benefits to be realized. If consumers refuse to trust in the reliability and safety of automated vehicle technologies, the likelihood of such vehicles on roadways is significantly reduced. As the related research suggests, many factors affect consumer adoption, from cost to perceptions of safety. However, despite the rapidly growing body of automated vehicle consumer research, we argue that the awareness and understanding of an AV’s operation have been overlooked. Specifically, what are consumer perceptions regarding an automated vehicle’s communication of overall status (e.g., fuel levels, sensor accuracy, operational status)? Further, what are consumer perceptions regarding communication of vehicle intent related to specific driving maneuvers and decision-making processes? It is important to learn how consumers envision an AV may or may not share vehicle operation status and decisions to understand how it may affect their trust and willingness to adopt them. To investigate this issue, we conducted an experiment using Amazon’s Mechanical Turk to study consumer perceptions of an AV’s ability to communicate and share information regarding its operational status and how it impacts their willingness to use them. This work contributes to understanding what people assume are an AV’s capabilities and what may be desirable, even necessary features, to increase trust and likelihood of adoption.

II. RELATED WORK

A. Consumer Perceptions of Autonomous Vehicles

With the rise in automated vehicle technology and the growing realism of fully autonomous (self-driving) vehicles on the road, researchers sought to learn about potential consumer perceptions of this emerging transportation technology. The perception and potential adoption of AVs have been explored in various contexts. The survey study by Howard and Dai [4] revealed that the most alluring aspects of AVs were perceived increased safety, the convenience of not driving, and multitasking but were concerned about factors such as cost, liability, and the loss of control. Similar concerns were expressed in other survey studies, such as equipment or

system failure, interactions with conventional vehicles, and security [5], [6]. Moody, Bailey, and Zhao [7] conducted an international study to understand AV safety perceptions. The responses were observed on different levels regarding socioeconomic groups, geographic locations, and individual differences. From an individual perspective, young males with high educational attainment and income and who are employed full-time have higher perceptions of AV safety, believe they are coming in fewer years, and have a greater intent to purchase than other respondents. The survey of Lee et al. found several factors that may predict the acceptance of self-driving vehicles, including perceptions of usefulness, affordability, confidence in using new technologies, and trust [8]. Additionally, young adults viewed AVs more positively than older adults and were more willing to accept them. Similar studies also reinforce the relationship between trust, perceived risk, usefulness, reliability, and legality and consumers' adoption of AVs, especially for older adults [9]–[11].

More recent research has focused on the perceptions of consumers with disabilities and aging adults, as they may benefit more from AVs than those who can operate a conventional vehicle. Opinions from people with visual impairments were generally positive because of the prospect of greater independence and personal mobility; however, concerns about their reliability, safety, cost, and legal implications made them less likely to purchase one [12]. Older consumers, in particular, were not ready to relinquish control of the vehicle and were just as wary of operating an AV for similar reasons [13].

B. Influence of Trust in Autonomous Vehicles

There is a level of trust surrounding AVs, and research suggests that trust begins to decline when faults appear. The work of Holländer, Wintersberger and Butz describes a study conducted using virtual reality ($N = 18$) where they presented a group with inaccurate information displays [14]. Their findings revealed that while participants began with a considerable measure of trust, it deteriorated when they viewed inaccurately reported messages. Another area of observing human-vehicle interaction is recognizing over trust/overreliance to curate the design process of the vehicle's external and internal cues. The internal cues of real-time fault diagnosis could ensure drivers are consistently made aware of specific traffic or vehicle situations. Primary guidelines may support reliable communication between drivers and their vehicles [15]. In-vehicle digital assistants are another intervention that could improve a passenger's riding experience. Studies show how an AV digital assistant providing the appropriate quantity and quality of information can influence a passenger's reliance on an AV's driving ability and, hence, improve their eagerness to ride one more frequently [16].

While increasing vehicle operation transparency may increase trust between passengers and AVs, careful consideration is needed concerning information overload and cognitive load. Cognitive load may impact how much information passengers may want to receive from AVs. Mirnig et al. studied how passengers in an automated shuttle bus handled the amount

of information provided on visual displays without a human driver [17]. The loss of the human component generated a greater dependence on the in-vehicle means of communication. The addition of geospatial details confused the passengers due to the cognitive overload experienced during their trip. In comparison, a passenger in a privately-owned AV may not face a similar issue. The study of Colley et al. [18] explored how visualizing semantic segmentation of internal vehicle information in the vehicle would impact a passenger's sense of trust, situation awareness, and cognitive load. The findings showed that the visualizations increased the situation awareness of the passengers without increasing the cognitive load.

We argue that the literature has not sufficiently examined how the amount of information provided and the level of detail of that information by AVs may affect consumers' perception of trust and desire for them. Our study explores the relationship between operational transparency across the dimensions of accountability, communication effort, information sharing, concerns, and consumers' intention to purchase an AV.

III. METHOD

We conducted a survey study to explore consumer perceptions of autonomous vehicles regarding their operational transparency. We draw on the work of Rawlins [19] for defining transparency as “the deliberate attempt to make available all legally releasable information, whether positive or negative in nature, in a manner that is accurate, timely, balanced, and unequivocal...”. Rawlins and Balkin [20] identified three dimensions of transparency: informational, participatory, and accountability. From the literature, in the context of autonomous vehicles, we define transparency as the vehicle's communication of its operational status, its environment's understanding, and its decision-making process. The constructed survey presents questions about operational transparency across four dimensions: accountability, communication effort, information sharing, and concerns. This study is a continuation from previous work focused on perceptions of transparency based on age and annual household income [21]. For this study we examine the same perceptions from based on race, gender, and disability.

A. Survey Instrument

We constructed a 65-question survey using two instruments: measuring transparency and trust in organizations [22] and measuring trust in automation and intention of use [23]. We also added questions regarding consumers' likelihood and willingness to pay for autonomous vehicles. For this paper, we present results from the analysis of the questions of Rawlins [22].

B. Participant Recruitment

We recruited participants through Amazon Mechanical Turk (MTurk) to participate in the study. Amazon MTurk is an online crowd-sourcing platform for recruiting 'workers' to accept and complete jobs administered by 'requesters,' who

compensate the workers upon completion. A common concern with experiments on Amazon MTurk is the data quality due to 1) workers with low or no reputation or approval ratings and 2) inattentive workers [24]. We restricted the sample to workers with a 95% approval rating and who have completed at least 5,000 jobs. This inclusion criterion would improve the likelihood that survey would be completed by more reputable workers who finish their tasks. We added several attention check questions (ACQs) in our survey to help participants focus on answering the questions as we intended. All ACQs contained the statement, “I am reading each question carefully (select XXX),” where XXX is one of the responses chosen for each specific question (e.g., select Strongly Agree). Workers who answered three or more ACQs incorrectly were not compensated for their assignment, and their data were excluded from the analysis. We decided on three ACQs as the exclusion threshold because we agreed that one incorrectly answered ACQ could be due to accidental actions such as misclicking. To ensure workers complete the survey fully, they had to enter into the MTurk assignment form the five-digit survey code generated by the survey once they completed all the questions.

C. Participant Demographics

In total, 1016 participants completed the survey, with 996 (668 male, 325 female, one non-binary, and two non-disclosed) included for analysis. We excluded 20 responses due to incorrectly answering three or more attention-check questions. Participant ages ranged from 18 to 79, with a mean of 34.73 and a standard deviation of 10.6. When observing racial and ethnic diversity, 49.8% identified as White, 31.9% as Asian, 5.8% as multiracial/mixed race, 5.7% as Black, 4.8% as Hispanic or Latinx, and 2.0% as American Indian or Alaskan Native. Annual household income ranged from under \$11,500 to over \$76,500. Regarding employment, 78.4% of participants work full-time, 14.1% work part-time, 5.0% are unemployed, 1.1% are students, 1.0% are retired, and less than 1% are disabled. For education, 66% of participants earned at least a Bachelor’s degree, 7.4% earned a professional degree, 11% attended some college, 7.1% obtained a two-year degree, 7.7% obtained a high school diploma GED, and less than 1% attended high school. Lastly, 10.8% of participants reported having a disability, with 36% reported having a visual disability, 25% having a motor disability, and auditory, cognitive, and other disabilities made up 13% of respondents each.

IV. RESULTS

Although the survey collected responses on 63 questions, we present findings on responses from the 39 questions of the survey on 1) accountability, 2) communication effort, 3) information sharing, 4) concerns about self-driving vehicles, and 5) their considerations for purchasing them.

A. Descriptive Analysis

We present descriptive statistics of the overall findings from the survey responses, broken down by the dimensions previously mentioned.

1) *Accountability*: There were six statements regarding consumer perceptions of the accountability of AVs in their decision-making. Table I shows all the breakdowns of the responses for each question. One of the questions (Q5) was an attention-check question.

For Q1, 68.6% of respondents believe AVs will be designed to understand how their decisions will affect them, versus the 17.1% who did not believe. Similar to Q1, most respondents (77.5%) believe AVs will be designed to provide useful information for making decisions, in contrast to 8.6% who were in disagreement. For Q3, 71% of respondents believe AVs will be accountable for its on-road decision-making and impact on passenger safety compared to 13.1%. The majority (67.2%) of respondents for Q4 believe that AVs will inform them of its actions and the rationale behind their actions, versus 13% who did not. Regarding Q6, 75.9% of respondents agreed that AVs share findings from the diagnostic scan of its system if it may be relevant to the passenger, while 7.6% do not believe. For Q7, 78.4% believe AVs will share updates and update system information with them and explain their meanings, whereas 7.3% disagreed.

TABLE I
QUESTIONS AND RESPONSES FROM THE ACCOUNTABILITY DIMENSION

Question Code	Question	% Agreed	% Disagreed
Q1	The autonomous vehicle will be designed to understand how its decision affects me	68.6%	17.1%
Q2	The autonomous vehicle will be designed to provide information that is useful to me for making informed decision	77.5%	8.6%
Q3	The autonomous vehicle will be designed to be accountable for the decisions it makes on the road and how they impact my safety	71%	13.1%
Q4	The autonomous vehicle will be designed to let me know what is doing and why it is doing it	67.2%	13%
Q6	The autonomous vehicle will be designed to share any findings from its diagnostic scan of its systems if it is relevant to me	75.9%	7.6%
Q7	The autonomous vehicle will be designed to share updates and updated system information with me and what it means to me	78.4%	7.3%

2) *Communication effort*: There were six statements regarding perceptions about an AV’s role in communicating to its owner. Table II shows the breakdown of the responses for each question. Q12 was an attention-check question.

TABLE II
QUESTIONS AND RESPONSES FROM THE COMMUNICATION DIMENSION

Question Code	Question	% Agreed	% Disagreed
Q8	The autonomous vehicle will be designed to ask for feedback from me about the quality of its information	61%	18.5%
Q9	The autonomous vehicle will be designed to help me identify the information I need	74%	10.6%
Q10	The autonomous vehicle will be designed to provide detailed information to me	72.3%	9.1%
Q11	The autonomous vehicle will be designed to make it easy for me to find information	76.8%	8%
Q13	The autonomous vehicle will be designed to ask for my opinions before making decisions	57.4%	28.6%
Q14	The autonomous vehicle will be designed to understand who I am and what I need	55%	24.9%

With Q8, 71% of respondents believe that AVs will ask for feedback about the quality of the information provided,

whereas 18.5%. For Q9, 74% of respondents believe that AVs will help identify the information they need, versus 10.6% who did not believe. Q10 saw 72.3% of respondents believing that AVs would provide detailed information, 9.1% did not. For Q11, 76.8% of respondents believe that AVs will make it easy for them to find information in the vehicle, versus 8%. With Q13, 57.4% of respondents, versus 28.6%, believe that AVs will ask for their opinions before making decisions. For Q14, 55% of respondents believe that AVs will take the time to understand them and their needs, compared to 24.9%.

3) *Information sharing*: There were seven statements regarding perceptions about the way AVs should share information with owners. Table III shows the breakdown of the responses for each question (there were no attention-check questions in this section).

In Q15, 79.8% of respondents believe that AVs will provide information in a timely fashion where 5.4% disagreed. For Q16, 80.4% of respondents believe AVs will provide relevant information, whereas 6.2% do not believe. For Q17, 67.4% of respondents believe that AVs provide information that is comparable to conventional vehicles, versus 13.9%. For Q18, 74.9% of respondents believe that AVs will provide complete, whole information, versus 8.5%. In Q19, 80.4% of respondents believe that AVs will provide information that is easy to understand, whereas 6.9% did not believe. In Q20, 81.4% of respondents, versus 5.5%, believe that AVs will provide accurate information. For Q21, 83.4% of respondents, versus 4.6%, believe that AVs will provide reliable information.

TABLE III
QUESTIONS AND RESPONSES FROM THE INFORMATION SHARING
DIMENSION

Question Code	Question	% Agreed	% Disagreed
Q15	The autonomous vehicle will be designed to provide information in a timely fashion	79.89%	5.4%
Q16	The autonomous vehicle will be designed to provide information that is relevant to me	80.4%	6.2%
Q17	The autonomous vehicle will be designed to provide information that is comparable to conventional vehicles	67.4%	13.9%
Q18	The autonomous vehicle will be designed to provide information that is complete	74.9%	8.5%
Q19	The autonomous vehicle will be designed to provide information that is easy to understand	80.4%	6.9%
Q20	The autonomous vehicle will be designed to provide accurate information	81.4%	5.5%
Q21	The autonomous vehicle will be designed to provide information that is reliable	83.4%	4.6%

4) *Concerns*: There were six statements asking consumers about their concerns regarding how AVs hide or refuse to disclose some or all information. Table IV shows the breakdown of the responses for each question (there were no attention-check questions in this section).

For Q22, 49.1% of respondents expressed concern that AVs may provide partial data to them, versus 32.4% who disagreed. For Q23, 46.2% of respondents expressed concern that AVs will leave out important details from the information it provides, while 35.6% were not concerned. In Q24, 50.6% of respondents did not feel concerned about AVs providing information that is intentionally delivered in a way to make it difficult to understand, while 32.7% felt concerned. For Q25, 42.9% of respondents were concerned about how slow

AVs may provide information to them, whereas 40.1% were not concerned. For Q26, 44.7% of respondents expressed concerns that AVs will only disclose information when they deem it required, whereas 24.4% were not concerned. For Q27, 55.4% of respondents expressed concern that AVs will share information about them with other people without their consent, versus 28.7% who were not concerned.

TABLE IV
QUESTIONS AND RESPONSES FROM THE CONCERNS DIMENSION

Question Code	Question	% Agreed	% Disagreed
Q22	I am concerned that the autonomous vehicle will provide only part of the story to me.	49.1%	32.4%
Q23	I am concerned that the autonomous vehicle will often leave out important details from the information it provides	46.2%	35.6%
Q24	I am concerned that the autonomous vehicle will provide information that is intentionally delivered in a way to make it difficult for me to understand	32.7%	50.6%
Q25	I am concerned that the autonomous vehicle will be slow to provide information to me	42.9%	40.1%
Q26	I am concerned that the autonomous vehicle will only provide information when it is required	44.7%	24.4%
Q27	I am concerned that the autonomous vehicle will share information about me to other people without my consent	55.4%	28.7%

5) *Likelihood to purchase based on information sharing*: The following three statements pertain to consumers' likelihood to purchase an AV based on its information-sharing behavior (see Table V for breakdown and responses). For Q43, 87.7% of respondents were likely to purchase an AV if it provides information about the status of its driving systems, versus 8% who were unlikely. For Q46, 50.3% of respondents were unlikely to purchase an AV if it does not provide information about the status of its driving systems, whereas 30.7% were likely. For Q47, 56% of respondents are unlikely to purchase an AV if it hides information about any problems in its driving systems, versus 30.7% who were likely.

6) *Likelihood to purchase based on communication*: The following three statements pertain to consumers' likelihood to purchase an AV based on its communication behavior (see Table V for breakdown). For Q42, 76.8% of respondents were likely to purchase an AV if it informs them about the decision it makes, versus 9.5% who were unlikely. For Q44, 65.2% of respondents were likely to purchase an AV if it allows them to provide feedback on its decisions, whereas 12.8% were unlikely. For Q45, 49.6% of respondents were unlikely to purchase an AV if it does not share information about the decision it makes, versus 33.2% who were likely.

7) *Willingness to pay*: Two statements asked participants' willingness to pay for automated driving capabilities in their next vehicle (Table VI). When asked how much extra beyond the price of a conventional vehicle they are willing to pay for an AV, 36.3% of respondents were willing to pay moderately extra, 25.9% would pay significantly extra, and 21.3% would pay slightly extra. When asked how much extra beyond a vehicle's base price for level 4 or higher automation, 38.2% of respondents was willing to pay moderately extra, 28.3% would pay significantly extra, and 17.1% would pay slightly extra.

TABLE V
QUESTIONS AND RESPONSES FROM THE LIKELIHOOD OF PURCHASING
DIMENSION

Question Code	Question	% Likely	% Unlikely
Q42	The likelihood of purchasing an autonomous vehicle if it would inform you about the decision it makes	76.8%	9.5%
Q43	The likelihood of purchasing an autonomous vehicle if it provides information about the status of its driving systems	87.7%	8%
Q44	The likelihood of purchasing an autonomous vehicle if it allows you to provide feedback on the decision it makes	65.2%	12.8%
Q45	The likelihood of purchasing an autonomous vehicle if it does not share any information about the decisions it makes	33.2%	49.6%
Q46	The likelihood of purchasing an autonomous vehicle if it does not provide information about the status of its driving systems	30.7%	50.3%
Q47	The likelihood of purchasing an autonomous vehicle if it hides information about any problems with its driving systems	30.7%	56%

TABLE VI
QUESTIONS AND RESPONSES FROM THE WILLINGNESS TO PAY DIMENSION

Question Code	Question	Slightly	Moderately	Significantly
Q48	How much extra beyond the price of a conventional vehicle are you willing to pay for an autonomous vehicle?	21.3%	36.6%	25.9%
Q49	How much extra beyond the base price of a vehicle would you pay for level 4 or higher automation?	17.1%	38.2%	28.3%

8) *Human-AV interactions*: There were four statements on consumer confidence interacting with an AV (Fig. VII). For Q50, 61.8% of respondents were confident in their ability to understand the status of the driving systems of an AV they owned, versus the 9.4% who were not very confident. For Q52, 56.9% of respondents were confident in their ability to understand the system failures reported by the AV, versus the 10.9% who were not confident. For Q53, 47.5% of respondents were confident in an AV to make decisions in emergencies, whereas 17.3% were not confident. For Q54, 48.9% of respondents were confident in AV to consider their feedback in the decision-making process, whereas 16% were not as confident.

TABLE VII
QUESTIONS AND RESPONSES FROM THE HUMAN-AV INTERACTION
DIMENSION

Question Code	Question	% Confident	% Not Confident
Q50	How confident would you be in your ability to understand the status of the driving systems of your autonomous vehicle?	61.8%	9.4%
Q52	How confident would you be in your ability to understand the system failures report by the autonomous vehicle?	56.9%	10.9%
Q53	How confident are you in the autonomous vehicle's ability to make decisions in emergencies?	47.5%	17.3%
Q54	How confident would you be in the autonomous vehicle's ability to take your feedback into consideration in the decision-making process?	48.9%	16%

B. Statistical Analysis

The following sections describe the findings from our statistical analysis to find any statistically significant effect of participant demographics on the responses to the questions. We performed the analysis using multiple one-way ANOVAs

and t-tests. We report only the results that were found to be statistically significant ($p < .05$, $p < .01$, $p < .001$).

1) *Race*: While there were six choices from which participants could choose, we conducted analyses on race in three groups, White, Asian, and Underrepresented (UR). The rationale comes from the research that shows concerns and barriers to adoption of AVs by underrepresented racial groups [13], [25], [26]. Table VIII shows the significance for all the questions based on race as a reference.

There was a significant effect of race on Q2 regarding accountability of AVs, where White participants ($M = 4.12$, $se = .058$) were more likely than Asian participants ($M = 3.84$, $se = .073$) to believe that AVs will provide useful information in making informed decisions on travel routes.

There were significant effects on questions Q8, Q11, Q13, and Q14 regarding the communication efforts of AVs. When asked about their beliefs regarding an AV designed to ask for their feedback about the quality of the information provided, Asian ($M = 3.78$, $se = .079$) were more likely than White ($M = 3.42$, $se = .066$) and UR ($M = 3.55$, $se = .045$) to believe this as a feature in the vehicle. White participants ($M = 4.17$, $se = .056$) were more likely than Asian ($M = 3.93$, $se = .081$) and UR ($M = 3.98$, $se = .039$) participants to believe AVs will make finding information easy to do. Regarding whether AVs will ask consumers for their opinions prior to making a decision, Asian ($M = 3.89$, $se = .081$) participants were more likely than White ($M = 3.12$, $se = .076$) and UR ($M = 3.87$, $se = .051$) participants to believe it would be a feature. Additionally, Asian ($M = 3.86$, $se = .074$) participants were more likely than White ($M = 3.14$, $se = .079$) and UR ($M = 3.36$, $se = .051$) participants in believing AVs will seek to understand their owner and their needs. We derive from the findings of this subset that Asian participants were generally more positive about the AV's ability to communicate with the owner than White and UR participants.

There were significant effects on questions Q15, Q16, Q19, Q20, and Q21 regarding the AV's ability to share information with owners. For every question, White participants were the most likely to believe some of the information-sharing behaviors exhibited by the AV over Asian and UR participants. This would suggest that White consumers expect the AV's system to present relevant (Q16) and accurate (Q20) information in a way that is easy to understand (Q19), reliable (Q21), and a timely fashion (Q15).

There were significant effects on questions Q22, Q23, Q24, Q25, Q26, and Q27 regarding concerns about the AV. In every question, White participants were the least concerned regarding the AV providing only partial information (Q22), leaving out important details from the information provided (Q23), delivering information in a way that may be difficult to comprehend (Q24), and only disclose information when it felt it was necessary (Q26). Additionally, White participants were the least concerned about the AV potentially sharing information about its owner with other people without consent (Q27). On the other hand, Asians were the most concerned in all of the questions.

For purchase considerations, Q43, Q45, Q46, Q47, Q48, and Q49. White participants ($M = 4.25$, $se = .061$) are more likely than Asian ($M = 3.98$, $se = .073$) participants to purchase an AV if it provides driving system status information but also are the least likely ($M = 2.24$, $se = .077$) if the AV does not provide any information. White participants ($M = 22.19$, $se = .078$) are less likely than Asian ($M = 3.49$, $se = .1$) and UR ($M = 2.62$, $se = .07$) participants to purchase an AV if it does not share any information about its decision-making process; also, White participants ($M = 1.93$, $se = .078$) are the least likely to purchase an AV if hides any information regarding problems with the driving system. When asked about their willingness to pay extra beyond a conventional vehicle for an AV, Asian ($M = 3.44$, $se = .079$) and UR ($M = 3.03$, $se = .045$) participants expressed paying moderately extra while White ($M = 2.78$, $se = .061$) participants expressed paying slightly extra. Similarly, Asian ($M = 3.37$, $se = .078$) and UR ($M = 3.1$, $se = .044$) participants expressed paying moderately extra beyond the base price of a vehicle for SAE level 4 or high automation, whereas White participants ($M = 2.95$, $se = .066$) on average would pay slightly extra.

In terms of confidence interacting with an AV, were significant effects on questions Q53, and Q54. Asian participants were the most confident out of the groups in the AV's ability to make emergency decisions ($M = 3.62$, $se = .076$) and integrate the owner's feedback into its decision-making process ($M = 3.62$, $se = .072$).

TABLE VIII
SIGNIFICANCE TABLE FOR RESPONSES BASED ON RACE

Question	F	dfn	dfd	p
Q2	4.49	2	406.14	.01
Q8	6.14	2	408.79	.002
Q11	4.74	2	391.18	.01
Q13	24.74	2	421.39	<.001
Q14	23.86	2	431.97	<.001
Q15	7.04	2	409.61	<.001
Q16	8.55	2	408.12	<.001
Q19	5.14	2	395.97	.01
Q20	7.88	2	403.43	<.001
Q21	10.77	2	395.53	<.001
Q22	16.45	2	420.46	<.001
Q23	21.57	2	415.59	<.001
Q24	40.9	2	422.97	<.001
Q25	43.02	2	424.23	<.001
Q26	9.49	2	414.06	<.001
Q27	13.11	2	420.51	<.001
Q43	4.46	2	414.5	.012
Q45	54.43	2	423.11	<.001
Q46	45.52	2	422.64	<.001
Q47	55.66	2	419.96	<.001
Q48	8.67	2	414.32	<.001
Q49	8.67	2	404.04	<.001
Q53	6.89	2	405.8	.001
Q54	7.59	2	411.89	<.001

2) *Gender*: While there were four choices (Man, Woman, Non-binary, Prefer not to say) with responses, the sample sizes for 'Non-binary' and 'Prefer not to say' were too small to run the analysis. Hence, only the analysis involving the Man

and Woman choices is discussed. Table IX presents statistical significance of the responses.

For accountability of AVs, there were significant effects of gender on statements Q3 ($F(1,584.12) = 4.55$, $P < .05$), Q6 ($F(1,725.03) = 12.15$, $P < .001$), and Q7 ($F(1,659.3) = 4.26$, $P < .05$). Women ($M = 4.03$, $se = .05$) were more likely than men ($M = 4.01$, $se = .04$) to believe that AVs will be accountable for the decisions it makes on the road and how it impacts their safety (Q3). Women ($M = 4.14$, $se = .05$) were more likely than men ($M = 3.93$, $se = .04$) that AVs will share results from their diagnostic scans (Q6). Women ($M = 4.11$, $se = .04$) were more likely than men ($M = 3.98$, $se = .04$) that AVs will share updates and updated system information and what it means (Q7).

For communication efforts of AVs, there were significant effects of gender on Q9, in which women ($M = 4.02$, $se = .04$) were more likely than men ($M = 3.84$, $se = .04$) to believe that AVs would help them identify the information they need.

For information sharing of AVs, there were significant effects of gender on Q15, Q16, Q18, Q20, and Q21. Women ($M = 4.27$, $se = .04$) were more likely than men ($M = 4.04$, $se = .04$) to believe an AV will provide information in a timely fashion (Q15). Women ($M = 4.26$, $se = .05$) were more likely than men ($M = 4.04$, $se = .04$) to believe an AV will provide information that is relevant to them (Q16). Women ($M = 4.13$, $se = .05$) were more likely than men ($M = 3.93$, $se = .04$) to believe an AV will provide information that is complete (Q18). Women ($M = 4.38$, $se = .05$) were more likely than men ($M = 4.18$, $se = .04$) to believe an AV will provide information that is accurate (Q20). Women ($M = 4.38$, $se = .05$) were more likely than men ($M = 4.21$, $se = .03$) to believe an AV will provide information that is reliable (Q21).

For concerns of AVs, there were significant effects of gender on Q24, where men ($M = 2.74$, $se = .5$) were more concerned than women ($M = 2.55$, $se = .07$) about AVs intentionally providing information difficult to understand (Q24).

For purchase considerations, there were significant effects of gender on Q43, Q45, Q46, Q47, Q48, and Q49. Women ($M = 4.24$, $se = .05$) were more likely than men ($M = 4.05$, $se = .04$) to purchase an AV if it provides the status information of its driving systems (Q43). Women ($M = 2.38$, $se = .08$) were less likely than men ($M = 2.79$, $se = .05$) to purchase an AV if it does not disclose information behind its decision-making process (Q45). Women ($M = 2.34$, $se = .07$) were less likely than men ($M = 2.77$, $se = .05$) does not provide status information about its driving systems (Q46). Women ($M = 2.14$, $se = .08$) were less likely than men ($M = 2.58$, $se = .06$) to purchase an AV if it hides information about problems in its driving systems (Q47). Regarding willingness to purchase an AV, men were willing to pay moderately extra ($M = 3.14$, $se = .04$) beyond the price of a conventional vehicle for an AV, while women were willing to pay slightly extra ($M = 2.82$, $se = .06$) (48). Men were willing to pay moderately extra ($M = 3.21$, $se = .03$) beyond the base price of a vehicle for level 4 or higher automation, while women were willing to pay slightly extra ($M = 2.9$ $se = .06$) (Q49).

In terms of confidence interacting with an AV, there were significant effects of gender on Q50, Q52, Q53, and Q54. Men ($M = 3.76$, $se = .04$) were more confident than women ($M = 3.49$, $se = .04$) in their ability to understand the status of the AV's driving systems (Q50). Men ($M = 3.67$, $se = .03$) were more confident than women ($M = 3.42$, $se = .05$) in their ability to understand the failures reported by the AV (Q52). Men ($M = 4.48$, $se = .04$) were more confident than women ($M = 3.2$, $se = .06$) in an AV's ability to make decisions in emergencies (Q53). Men ($M = 3.49$, $se = .04$) were more confident than women ($M = 3.24$, $se = .04$) in AV's ability to take their feedback into consideration during their decision-making (Q54).

TABLE IX
SIGNIFICANCE TABLE FOR RESPONSES BASED ON GENDER

Question	F	dfn	dfd	p
Q3	4.55	1	584.12	<.05
Q6	12.15	1	725.03	<.001
Q7	4.26	1	659.3	<.05
Q9	7.83	1	692.56	<.01
Q15	15.85	1	748.51	<.001
Q16	14.24	1	718.73	<.001
Q18	9.39	1	702.48	<.05
Q20	10.55	1	705.89	<.001
Q21	9.07	1	685.22	<.01
Q24	4.43	1	671.45	<.05
Q43	7.96	1	691.01	<.01
Q45	17.67	1	616.58	<.001
Q46	22.27	1	660.31	<.001
Q47	20.86	1	661.79	<.001
Q48	19	1	598.23	<.001
Q49	17.08	1	562.8	<.001
Q50	18.169	1	634	<.001
Q52	15.1	1	625.18	<.001
Q53	14.89	1	589.22	<.001
Q54	14	1	623.52	<.001

3) *Disability*: Dependent t-tests were performed to test for the effect of the presence/absence of a disability on the responses (see Table X).

For accountability of AVs, there were significant effects of disability on statements Q3 with non-disabled persons ($M = 3.89$, $se = .03$) more likely than disabled persons ($M = 3.6$, $se = .01$) to believe that AVs will be accountable for the decisions it makes on the road and how it impacts their safety.

For communication efforts of AVs, there were significant effects of disability on Q11 where non-disabled persons ($M = 4.05$, $se = .03$) were more likely than disabled persons ($M = 3.76$, $se = .01$) to believe that AV will make it easy for them to find it.

For information sharing of AVs, there were significant effects of disability on Q15, Q18, Q19, and Q21. Non-disabled persons ($M = 4.14$, $se = .03$) were more likely than disabled persons ($M = 3.87$, $se = .01$) to believe that AVs will provide information in a timely fashion (Q15). Non-disabled persons ($M = 4.03$, $se = .03$) were more likely than disabled persons ($M = 3.73$, $se = .01$) to believe that AVs will provide information that is complete (18). Non-disabled persons ($M = 4.15$, $se = .03$) were more likely than disabled persons ($M = 3.91$, $se = .04$) to believe that AVs will provide information that is

easy to understand. Non-disabled persons ($M = 4.29$, $se = .05$) were more likely than disabled persons ($M = 4.21$, $se = .03$) to believe that AVs will provide information that is reliable (Q21).

For concerns of AVs, there were significant effects of disability on Q22, Q23, Q24, Q25, and Q27. Disabled persons ($M = 3.55$, $se = .1$) were more concerned than non-disabled persons ($M = 3.19$, $se = .04$) about AVs providing only part of the information (Q22). Disabled persons ($M = 3.41$, $se = .1$) were more concerned than non-disabled persons ($M = 3.11$, $se = .04$) about AVs leaving out details from the information that it provides (Q23). Disabled persons ($M = 3.21$, $se = .1$) were more concerned than non-disabled persons ($M = 2.61$, $se = .04$) about AVs intentionally providing information difficult to understand (Q24). Disabled persons ($M = 3.62$, $se = .1$) were more concerned than non-disabled persons ($M = 2.91$, $se = .04$) about AVs being slow to provide information (Q25). Disabled persons ($M = 3.64$, $se = .1$) were more concerned than non-disabled persons ($M = 2.34$, $se = .04$) about AVs sharing information about them to other people without their consent (Q27).

For purchase considerations, there were significant effects of disability on Q45, Q46, Q47, Q48, Q49. Non-disabled persons ($M = 2.57$, $se = .04$) were less likely than disabled persons ($M = 3.35$, $se = .1$) to purchase an AV if it does not disclose information behind its decision-making process (Q45). Non-disabled persons ($M = 2.55$, $se = .05$) were less likely than disabled persons ($M = 3.23$, $se = .1$) to purchase an AV if it does not provide status information about its driving systems (Q46). Non-disabled persons ($M = 2.34$, $se = .04$) were less likely than disabled persons ($M = 3.19$, $se = .1$) to purchase an AV if it hides information about problems in its driving systems (Q47).

Regarding willingness to purchase an AV, disabled persons were willing to pay moderately extra ($M = 3.59$, $se = .1$) beyond the price of a conventional vehicle for an AV, while non-disabled persons were willing to pay slightly extra ($M = 2.97$, $se = .04$) (48). Both disabled ($M = 3.04$, $se = .03$) and non-disabled ($M = 3.63$, $se = .1$) persons were willing to pay moderately extra beyond the base price of a vehicle for level 4 or higher automation (Q49).

In terms of confidence in an AV, there was a significant effect of disability on Q53 with disabled persons ($M = 3.62$, $se = .1$) more confident than non-disabled persons ($M = 3.36$, $se = .03$) in an AV's ability to make decisions in emergencies (Q53).

V. DISCUSSION

Our study sought to show the varying degrees of consumer perceptions across four dimensions (i.e., accountability, communication, information sharing, and concerns about autonomous vehicles).

A. Accountability

Regarding race, gender, and ability, there are significant differences in the views of accountability in AVs. UR and

TABLE X
SIGNIFICANCE TABLE FOR RESPONSES BASED ON DISABILITY

Question	t	df	p
Q3	2.37	130.04	<.05
Q11	2.66	126.71	<.01
Q15	2.59	126.37	<.05
Q18	9.39	702.48	<.05
Q19	2.22	126.11	<.05
Q21	2.22	129.57	<.05
Q22	-3.04	140.36	<.01
Q23	-2.3	136.14	<.05
Q24	4.43	671.45	<.05
Q25	-5.57	137.69	<.001
Q27	-2.4	141.19	<.05
Q45	-5.61	135.66	<.001
Q46	-5.03	135.67	<.001
Q47	-5.68	133.07	<.001
Q48	-6	135.86	<.001
Q49	-5.2	129.52	<.001
Q53	-2.48	133.37	<.05

White respondents were the most likely to believe AVs will be accountable for their decision-making. While women were more likely to believe AVs would be accountable for their actions than men. Men were willing to pay more for AV technology than women and were more confident to interact and accept the actions of the AVs. Those with a disability also have more confidence in an AV's ability to make decisions and take their input.

Similarly, consumers' desire to purchase an AV depends on their belief in accountability. For example, white respondents will purchase an AV if it provides status information, while underrepresented respondents are the most likely to purchase it if it does not communicate or share information. Regarding paying beyond the price for a conventional vehicle for an AV, UR and Asian participants were willing to pay moderately extra; White participants slightly extra. Additionally, UR and Asian participants were willing to pay moderately extra beyond the price of a vehicle for level 4 or higher automation; White participants slightly extra.

B. Communication

Respondent's beliefs toward autonomous vehicles based on communication differed by racial group. For example, Asian respondents believe that the AV will get feedback from a passenger about information quality. On the other hand, Whites believe that the AV will make information easy to find, while Asians believe that AVs will understand their owners and their needs. Gender also plays a significant role in beliefs. For example, women are more likely to believe AVs will communicate information than men.

While little research exists in examining the attitudes of people with disabilities regarding autonomous vehicles, the work of Brinkley et al. [12] showed that people with visual impairments were generally positive about autonomous vehicles and their potential benefits. In our study, Disabled persons were the most concerned about the communication of AVs but the most willing to purchase them.

C. Information Sharing

Our findings suggest that information sharing does play a significant role in consumers' perceptions of AVs. White respondents were the most likely to believe AVs would share information with them. Additionally, White respondents are more likely to purchase an AV if it provides status information. Conversely, multiracial respondents were the least likely to purchase an AV if it does not communicate nor share information.

Overall, when respondents were presented with more than fewer information options, the preference was clearly for more information. When viewed within the context of the related AV literature, this finding suggests that consumer information preferences within self-driving vehicles may mirror the related desire for optional manual control. For example, studies by Schoettle and Shivak [6] and KPMG [27] have suggested that most potential AV consumers, who may be viewed as operators of this technology, prefer self-driving vehicles with some form of manual control of steering, acceleration, and braking.

Our findings suggest that in addition to manual controls, these operators of self-driving vehicles similarly desire fine-grained details about the vehicle's decision-making processes and operational status, which we describe within this work as transparency.

D. Concerns of Autonomous Vehicles

Recent research on self-driving vehicles suggests that many consumers are concerned that this technology will not function reliably [27], [28]. While we did not directly investigate risk, trust, and safety within this research, we argue that it is only slightly speculative to conclude that our respondents strongly favored full transparency to mitigate the perceived risk of autonomous vehicle use. Asian and UR respondents expressed the highest level of concern about AVs hiding information. Men were more concerned about AVs hiding information than women. Disabled persons were the most concerned about AVs' communication and information sharing but the most willing to purchase them. This is because they have more confidence in an AV's ability to make decisions and take their input. In addition, respondents perceive that AVs provide what they believe to be important information in real time.

E. Limitations

There were some limitations that impacted the study to which we discuss in this section. The most notable limitation is the use of Amazon Mturk to crowdsource survey participants. Despite the parameters in place to recruit more reputable workers, it does not fully prevent those who may satisfice surveys (providing the minimum effort required to satisfy completion requirements). Although all participants were from the US, we did not collect regional or state-level data to infer differences of perceptions based on specific regions of the country. The survey was focused on perceptions of autonomous vehicle transparency and its impact on likelihood to obtain one. Another avenue worth exploring is the perceptions of transparency and its effect of perceptions of trust of

autonomous vehicles as trust is a crucial factor in determining a person's willingness to adopt and buy them.

VI. CONCLUSION

As we continue to see autonomous vehicles become a commercial reality for public consumption, consumer acceptance and adoption will depend on their ability to feel comfortable with relinquishing control of the vehicle and trust the information it provides. Our work examined consumers' perceptions toward accountability, communication, information sharing, and concerns about autonomous vehicles across race, gender, and ability on autonomous vehicles. Results from this study suggest that people are generally positive regarding an AV's ability to communicate and share important operational information with them effectively and are likely to desire and buy an autonomous vehicle. This holds true, especially for those with a disability and minoritized racial groups. We also see the same groups express concerns about AVs hiding most or all crucial details about their decision-making, not considering their feedback, and potentially sharing sensitive information without their consent. The findings align with past research showing how automated vehicle technology is appealing and presents many benefits over conventional vehicles. However, the uncertainty behind its capabilities and how it interacts with passengers cause concern. In future work, we will take a more in-depth look at the kind of information consumers would expect to learn from AVs, what the information would look like, and how such information would be presented. This work is an ongoing investigation into creating a safe and accessible in-vehicle experience of autonomous vehicles.

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