Perceived Criminal Liability: Non-Lethal vs. Lethal Situations Involving Autonomous Vehicles and Drivers

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As more vehicles with semi-autonomous features are being used on the road, the question of who is liable in an accident becomes less clear. In this study, we recruited participants from the auto industry, law enforcement, and the general public and presented four different scenarios in which semi-autonomous vehicles were involved in lethal and non-lethal accidents, where take-over requests either occurred and were obeyed or did not occur. In-depth interviews were conducted with select participants to gain additional insight into their answers. Participants were asked to rank the severity of each accident and rank the liability of the manufacturer and the driver in the accident. Our study found that the industry respondents work in has a significant influence on their familiarity with autonomous vehicles, but no influence on how they choose to assign liability between the manufacturer and the driver. Additionally, participants all assigned some degree of liability to both the manufacturer and the driver across all scenarios. These results were inconclusive, but this may indicate an uncertainty around other factors that might help respondents attribute liability and further research should be done to account for these factors.

General Terms: Human Factors, Autonomous Vehicles

Additional Keywords and Phrases: *semi-autonomous vehicles; liability; human-automation cooperation*

1. INTRODUCTION

As the reality of fully autonomous vehicles (AVs) becoming a dominant presence on public highways nears, the population of vehicles already equipped with varying levels of self-driving functionality is already here and increasing. Semi-autonomous vehicles are defined as “motor vehicles…that can operate for extended periods with little human input” and may be equipped with varying levels of autonomous driving features (Society of Automotive Engineers, 2018a). The SAE defines semi-autonomous vehicles as having “conditional automation” at level 3 or “high automation” at level 4 (Society of Automotive Engineers, 2018b). While these features can help assist with driving functions and occasionally perform more accurately than a human driver, the assistance they provide comes with a risk for distraction via all channels: visual (eyes off the road), manual (hands off the wheel), and cognitive (mind off the road), which does not fully eliminate the possibility of accidents (Centers for Disease Control and Prevention, 2011).

To compensate for these known risks, many semi-autonomous driving systems include some version of a safeguard to retain the driver’s attention, signal to the driver that their intervention is required, or to bring the vehicle safely to a stop if the driver fails to obey the requirements of the features continued use. A common form of this is a take-over request (TOR). As defined by the SAE, a take-over request is a “notification by the ADS to a human driver that he/she should promptly begin or resume performance of the dynamic driving task (DDT)” in a level 3 or 4 automated driving system (Society of Automotive Engineers, 2018a). These safety features are a key incentive to AV adoption and OEMs successfully marketing their AVs to consumers, as people who have been involved in vehicle accidents perceive AV safety as a desirable attribute “if it is known to be safer than an average human-driven vehicle” and “if the car company would be liable for possible accidents” (Shabanpour, et. al, 2018).

The ethics of liability for incidents involving AVs is a topic that has been discussed in legal and philosophical journals, mostly in the context of fully AVs or in the context of developing AV technology, some of which conclude “no driver could ever be ‘absolutely without fault’ if his [autonomous] vehicle runs into another human being” (Dietrich, et al., 2020, p.12-17) (Hevelke & Nida-Rümelin, 2014, p.628). However, far more semi-autonomous vehicles are currently on the road interacting with traditional drivers, and more than just manufacturers play a crucial role in designing systems that drivers can use safely. For example, in March, 2019, a Tesla Model 3 was being driven by the vehicle's semi-autonomous Autopilot system. The driver engaged with the Autopilot about 10 seconds before a fatal collision with a tractor-trailer, but the vehicle did not detect the driver's hands on the steering wheel. The Autopilot system was found at-fault, because its functions and limitations contributed to the crash (National Transportation Safety Board, 2019).

When considering assigning liability, "possibilities are the on-board user, the OEM branding the vehicle, the supplier providing the automation or the individual contractor writing the code – each of which comes with its own advantages and disadvantages" (Dietrich, et al., 2020, p.13). The question of who can be held liable in semi-autonomous crashes becomes more difficult to answer as more parties play a role in ensuring the vehicle operates in a safe manner (Boafo & Pratt, 2016). "Liability for incidents" is also a concern documented that may vary between different demographics of drivers (Thomas, et al., 2020), though there are few studies that have aimed to understand how those demographics would rank liability in real-world or theoretical accidents.

In this exploratory study, we aim to discern what factors in an accident involving a semi-autonomous vehicle affect people's ability to optimally assign criminal liability in different scenarios and to determine where possible biases exist. Responses from groups that hold a stake in the use of AVs - automotive, law enforcement, and the public - will be cataloged from a survey asking a series of questions about AV familiarity and scenarios, and from in-depth interviews conducted with select participants after the fact.

2. BACKGROUND STUDIES

There is evidence that incidents involving autonomous or self-driving vehicles are perceived differently due to how an observer feels about an incident (affect heuristics), generating bias about the severity of the crash or of the safety of the autonomous system involved. Participants in this study perceived crashes involving self-driving vehicles to be of higher severity, regardless of whether there were minor injuries or fatalities (Liu, P., Du, Y., & Xu, Z. 2019). Affect heuristics can be tagged and tracked. In contrast, another study examined scenarios where a human driver and a second driver – either another human or an autonomous one – made errors and found the blame was attributed more toward the human driver than the machine (Awad et al., 2019).

Some researchers held that attributions of blame and responsibility depend on contextual factors (Hevelke & Nida-Rümelin, 2015). In a study exploring AVs making choices on their own, participants showed more outrage toward AVs that made moral choices on their own to reduce accident severity (i.e., A vehicle choosing to kill an elderly person instead of a child when an accident was unavoidable), and attributed blame more heavily toward the manufacturer of the vehicle in those scenarios (De Freitas & Cikara, 2021). As the level of automation in a vehicle and behavior of the vehicle can influence the perception of an accident, we wanted to examine how the functioning of a vehicle's autonomous feature prior to an accident might influence the perception of who is liable for that accident.

3. METHODS

3.1 Research Question

Our study aims to examine the following main questions: How do those in different industries - auto, law enforcement, and the public - view liability in accidents where semi-autonomous vehicles are involved? Are these perceptions affected significantly by the lethality of the accident and the behavior of the vehicle's semi-autonomous system? Additionally, does the level of familiarity with semi-autonomous vehicles have a significant impact on how liability for incidents is attributed?

Due to the impact semi-autonomous vehicle features have on driver mental workload when the driver is engaged in both driving and another secondary task, the presence or absence of a TOR was chosen as an independent variable based on studies that linked driver attentiveness to the frequency and severity of automobile accidents (Ferdinand & Menachemi, 2014). For our study, we also determined that measuring familiarity with AVs would serve as a positive affect heuristic to attribute to liability responses.

3.2 Participants

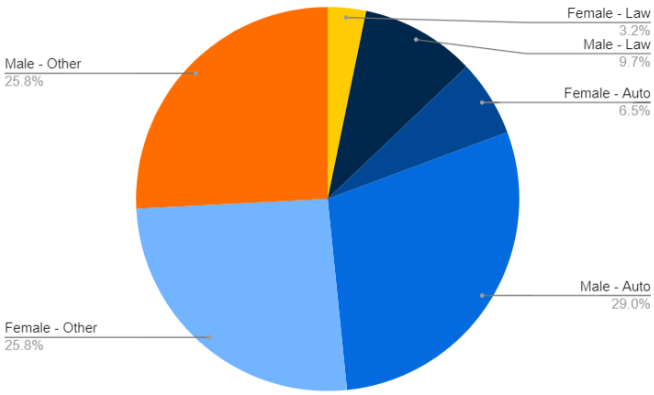
48 initial participants were recruited from the three selected populations – members of law enforcement, automotive industry employees, and members of the public (with professions belonging to neither specific group). We chose to select participants from these specific groups due to how their industry status may influence their perception of accidents and liability. Recruitment of participants was accomplished via direct referrals from research team members, ads published on major social media platforms (ie. Instagram), and targeted searches via Linkedin for those meeting study criteria and using InMail or 2nd degree connections for email.

To ensure demographics were balanced, 8 participants from the auto population and 7 participants from the public/other category were dismissed, bringing the total to 33 participants. All participants selected were 18 years of age or older, with average age distributions as follows: law enforcement 45.6; automotive 29.7, and public/other 40 (see Figure 8 in Appendix B). Law enforcement contained 2 females and 9 males, corporate automotive, and other industries contained 5 females and 6 males (Figure 1).

For the in-depth interviews, select survey participants were given the option to attend an additional interview. Two participants from each industry volunteered to be interviewed.

Figure 1

Distribution of Gender by Industry of Survey Participants.



3.3 Survey Design

The first part of the survey was composed of questions addressing the participants prior experience with AVs and their general opinion of the technology, based on similar questions asked in prior studies assessing public opinion about AVs (Kyriakidis, Happee, & de Winter, 2014). Familiarity questions were asked prior to the scenarios and accounted for the affect heuristic of experience with AVs among our different industries. The survey also included 3 questions to assess the participants' views surrounding the importance of liability, but we ultimately did not feel these questions were relevant to our study and were not included in the results.

We developed four hypothetical accident scenarios as part of the survey. We specifically referenced questions from prior studies that asked participants to assess blame attribution between the driver and the vehicle/manufacturer after being presented with a scenario in which the vehicle kills a person of a preferred group over another (De Freitas, & Cikara, 2021). The "accident scenario" structure was replicated to present our variables to the participants. Our study is a within-subjects design; therefore all scenarios were presented to each participant. To avoid predictive bias, these scenarios were presented in a randomized order. Scenarios were designed to deliberately limit the information available to a possible observer of the incident to the selected independent variables - automation behavior (TOR request/ no TOR) and severity of the incident (resulting in minor injuries or damage/fatality) (Figure 2).

Figure 2

Matrix of Independent Variables by Scenario

Incident 1	**Incident 2**
No TOR/Non-lethal	No TOR/Lethal
Incident 3	**Incident 4**
TOR/Non-lethal	TOR/Lethal

For each scenario, participants were asked the same four questions: "How liable is the manufacturer in this accident?" "How liable is the driver in this accident?" "How severe do you perceive this accident?" "How much does the severity of this accident influence your liability selections?"

The survey was built within - and administered using - Qualtrics. Two rounds of pilot testing were completed to further refine questions based on test participant feedback prior to the official study. Pilot testers suggested adding a graphic to familiarize the participants with levels of Driving Automation defined by the SAE (Society of Automotive Engineers, 2018b) within the survey, and this chart was added as a result. Additionally, we refined our measurement techniques, breaking the liability questions into two questions that could both be measured on a Likert scale (How liable is the manufacturer? How liable is the driver in this accident?). The results of the pilot testing were not recorded as part of the official survey results.

The survey took participants an average of 8 minutes to complete and participants were compensated for their efforts with a chance to win a 15$ value Gift Card.

3.4 Interview Design

In-depth interviews were conducted with 6 participants from the population who had already taken the survey and took an average time of 24 minutes to complete. Participants signed consent forms prior to the interviews and agreed to be recorded. All interviewees were first given an overview of level 3 automation before being asked open-ended questions about their familiarity, usage, and views on autonomous vehicles. During the second half of the interview, participants were read the same scenarios that were included in the survey and asked to answer different, open-ended questions (see full list of interview questions in Appendix D). These questions focused on participant's perception of the incident, feelings surrounding the severity of the accident, and who they felt was more liable for the accident and why.

4. ANALYSIS

4.1 Survey Results

Since our survey was composed of questions with responses along an ordinal 1-7 Likert scale, results from Qualtrics were imported to Minitab, and the responses were re-coded from text to numeric values. To test the impact of the affect heuristic we chose to examine (familiarity with AVs), the numeric results of Q7, Q8, and Q9 were added together to create an overall familiarity score (see Figure 9 in Appendix B for variance). On average, those in the "Auto" field had the most positive associations with AVs. The "Other" field had more distributed responses, and "Law" ranged from neutral to moderately positive (Figure 3). The questions asked were:

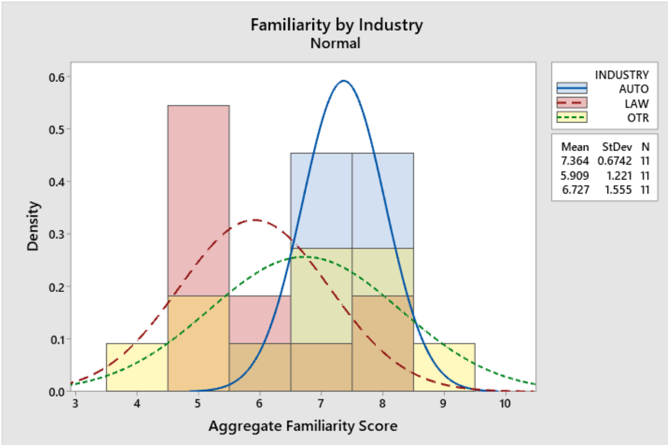
Q7 - Have you ever heard of an "autonomous vehicle" before (e.g. autonomous cars, autonomous shuttle, autonomous bus, etc...)?

Q8 - Have you ever taken a ride in an autonomous vehicle before?

Q9 - What is your general opinion regarding autonomous and self-driving vehicles?

Figure 3

Familiarity Analysis by Industry



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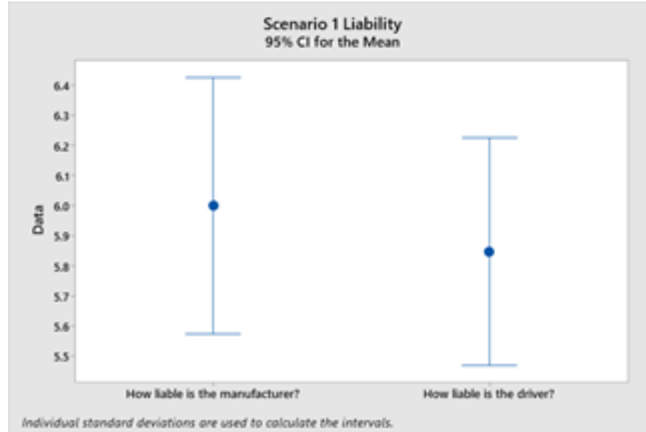
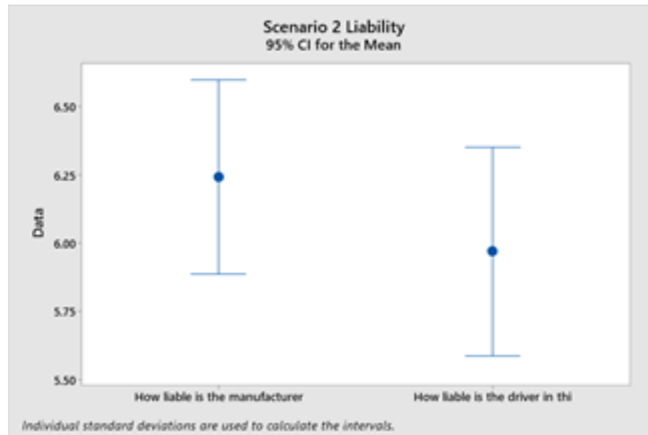
Since this data appeared to meet the necessary assumptions, an ANOVA was then run on the data for correlation between familiarity score and the field of the participant. The p-value of 0.028 ($\alpha = 0.05$) indicated that there was a significant difference in some of the response means by job field (see Table 1 in Appendix C). Post-hoc analysis using a Tukey's HSD found that the pair with the most significant difference was automotive vs. law enforcement, with a p-value of 0.022. The other pairings of groups were found to have p-values above the significance threshold ($\alpha = 0.05$) and thus we could conclude a significant difference between those groups. (see Figure 9 in Appendix B).

As for the data related to the scenarios, the majority of data sets could not reliably meet all the necessary assumptions of traditional parametric tests. We opted not to exclude outliers due to our small sample size, which also limited the available statistical tests we could run on our scenario responses (Ghasemi & Zahediasl, 2012). Enough of our data did not meet many of the assumptions to run various non-parametric tests, which were not ideal for analyzing all scenarios (aside from the median-based Mann-Whitney or Wilcoxon signed-rank tests used on the liability questions). We accepted that statistical analysis may not yield usable results in our study. Therefore, we compared the responses via graphical methods and mean values to obtain a general overview of how participants responded to the scenario questions via industry (see Figures 10-13 in Appendix B). However, due to the small sample size, we were not able to find any significant difference between how the industry groups answered scenario questions. We generated a summary of means values (see Table 2 in Appendix C) and interval plots to instead compare the mean liability distributions by general population (N33) in each scenario, such as in Figure 4.

Figure 4

Scenarios 1 & 2 Liability Interval Plot

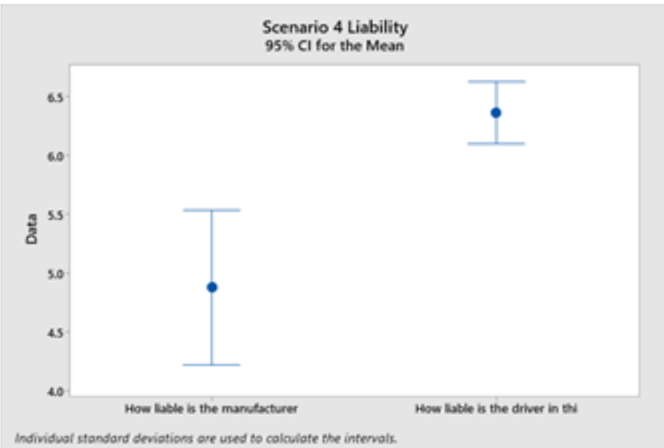




In all scenarios, respondents ascribed both the driver and manufacturer "slightly liable" to "completely liable". For the first two scenarios, the manufacturer was found slightly more liable on average. Scenario 1 indicated a difference in mean of 0.151, and scenario 2 a difference of 0.272, indicating a slightly higher attribution of liability toward the manufacturer and less toward the driver when TOR was absent. Scenarios 3 and 4 placed more liability on the driver than the manufacturer with a tighter distribution of the responses toward "moderately liable" or "completely liable", with scenario 3 having a difference in means of -1.636 and scenario 4 a difference of -1.484 (Figure 5). In the accident scenarios with a TOR present and human intervention, regardless of lethality, responses were more polarized, indicating less uncertainty from the respondents about whom they found liable when a human resumed control, but the accident occurred anyway.

Figure 5

Scenarios 3 & 4 Liability Interval Plot



We tested to determine whether the responses to “How liable is the manufacturer in this accident?” and “How liable is the driver in this accident?” were significantly different in all scenarios, due to the differences in means being so slight. It should be noted that the differences between the means of each questions’ responses may not be statistically relevant. Utilizing median-base statistical tests (Mann-Whitney or Wilcoxon signed-rank) to accommodate non-normally distributed data resulted in no significant difference in the median data of each scenario.

The questions “How severe do you perceive this accident?” and “How much does the severity of the accident influence your liability selections?” were also examined for possible relationships to liability ratings. In scenarios 2 and 4, where the accident described resulted in a fatality, mean perceived severity ratings were high (6.727, 6.727) and were the same regardless of whether there was a TOR request present or not. In addition, when asked how much the severity influenced their decision, both mean ratings were also high and similar to each other (5.636, 5.465). However, the mean liability was lower for the manufacturer in scenario 4 compared to 2 (4.879, 6.242), which indicates that the severity score did not have an influence on the average answer given in these two scenarios.

In scenarios 1 and 3, where the accident described did not result in a fatality, mean severity ratings differed. The mean severity rating for scenario 1 was 5.697 and 4.455 for scenario 3. In addition, The mean liability was lower for the manufacturer in scenario 3 compared to 1 (4.515, 6). This indicates that in situations where a minor accident occurs, the presence or absence of a TOR does have an impact on perceived severity and liability distribution.

4.2 Interview Results Sentiment Analysis

Transcripts of the in-depth interviews were imported to NVivo for qualitative data analysis, where the interviewees’ responses were coded and then processed for sentiment analysis from “positive” to “negative”. Our results show a much higher weighted percentage and frequency of negative sentiment in all responses to open-ended questions about each scenario (see Tables 3-5 in Appendix C for a complete analysis). Interviewees described fatal accidents (scenarios 2 and 4) most frequently with feelings of disappointment, sadness, anger, and frustration, reactions and emotions associated with grief and loss (Figure 7). On the other hand, scenarios where minor injuries and damage occurred (scenarios 1 and 3) were described most frequently with feelings of disappointment, annoyance, anger, and confusion (Figure 6).

There was an interesting comparison demonstrated by interviews between a participant in the auto group compared to a participant from the law enforcement group. For the *auto-participant,* there was an inclination to assign liability to both the driver and the OEM, while the liability seemed to fall farther on the side of the OEM for the *law-participant*. The *auto-participant* commented on their selection scenario 1 on liability, “I think the driver always has some liability and responsibility, because they’re the ones in the driver’s seat, and they can always intervene anytime,” adding, “But I think it would be a fault of the system to not send a warning message. It appears that it did not operate correctly.” The *law-participant* states for the same question, “Well, like anything, whoever’s manufacturing something has the moral responsibility to make sure that everything is done safely.” They also add, “Manufacturers are held to a certain standard, so I don’t hold the drivers fully responsible if the expectation is that the vehicle is supposed to operate the way it’s marketed [...] I don’t expect passengers of the elevator to be liable for it, I expected the elevator to go down. [...] if doesn’t happen that way, why would I be liable for that?” It should also be noted that all interview participants stated at several points that there are too many potential variables or details that were not explicitly mentioned that would help them more accurately determine liability.

Interviewees in law enforcement and automotive responded that they would utilize an ADAS feature in the early morning on the highway when there’s fewer cars or traffic to avoid situations that would raise the risk of crashes. In addition, they expected car salesmen to be able to explain all a vehicle’s driverless technology systems in great detail. Individuals in other fields expressed interest in experiencing an ADAS system’s convenience to navigate traffic jams and congestion to work, and to potentially sleep, read, eat, engage with other passengers/children, or watch TV while “driving”. At the same time, they also desired the ability to take over and control the vehicle at any time to “avoid crashes” or navigate the vehicle out of risky situations.

Figure 6

Scenario 1 Sentiment Analysis

Word	Length	Count	Weighted Percentage	Similar Words
disappointment	14	9	4.84%	disappointed, disappointme nt
frustrated	10	7	3.76%	frustrated, frustration
annoyed	7	6	3.23%	annoyance, annoyed
anger	5	5	2.69%	anger

Figure 7

Scenario 3 Sentiment Analysis

Word	Length	Count	Weighted Percentage	Similar Words
disappointment	14	8	4.23%	disappointed, disappointme nt
sad	3	7	3.70%	sad, sadness
confused	8	6	3.17%	confused, confusion
angry	5	5	2.65%	angry
concerned	9	4	2.12%	concerned

From those participants who replied with “concern”, 3.03% worked in law enforcement, 6.06% in the auto industry, and 3.03% in other fields.

5. DISCUSSION

5.1 Interpretation of Results

The sample size for our study was relatively small (N=33 for survey responses and N=6 for interviews), which may have impacted the significance of the results we obtained. In all scenarios, participants held both the manufacturer and driver somewhat liable for the accident, indicating there may be many more confounding factors (such as environment or unexpected events) influencing their perception of liability, as was also noted by participants of the interview. When prompted to assign fault between both parties, it is more difficult for the participant to determine who is more at fault, and the factors that influenced their choices are inconclusive.

5.2 Constraints and Limitations

We had difficulty recruiting a balanced number of participants within each industry. This was partially due to time constraints and finding a substantial number of law-enforcement participants to match the number of auto and public participants. For future studies in liability, we would increase the sample size to obtain more significant results, or we would remove the industry categorizations from participant groups and instead recruit from the general public.

Members of the law enforcement community who were active-duty police officers were less available to participate in the in-depth interview portion of the study due to specific restrictions and additional time required to obtain permission requirements from their higher-ups. Two participants from the law enforcement field were able to provide an interview, but this did limit our ability to collect additional interviews from other fields.

We also encountered gender disparity among the law enforcement participants, making it difficult to achieve gender parity in our sample within our study’s allotted timeframe. Gender distribution across full-time, US law enforcement officers is 12.8% female and 87.2% male (Duffin, 2020). While we did not test any of our study variables against gender demographics, this did result in law enforcement having the least balanced gender distribution across the study, making up 27.27% of males and only 6.06% of the females.

TOR timeframes and driver response times were not specified in the scenarios, forcing participants to speculate on their own whether it may have been a factor in the accident or not. Specifying the time allotted by the take-over request may have given participants additional context, since it has been found that “drivers take longer to resume control when under no time pressure”. The time it takes to resume control of the vehicle after a TOR has been prompted by the vehicle was found to be approximately 4.46 ± 1.63 s when the driver was not occupied with another task and increases to approximately 6.06 ± 2.39 s when the driver is engaged in another, non-driving task (Eriksson & Stanton, 2017). This may have been a specific confounding variable we failed to account for and should be included in future scenario designs using these documented TOR figures.

6. CONCLUSIONS

While our exploratory study provided inconclusive results, the design could serve as a possible framework for future studies. Results could provide a background for future legislation surrounding AVs and insight for OEMs about consumer opinions about AV adoption. Without much precedent in the world for interpreting semi-autonomous accidents, it is also possible that there are heuristic influences other than AV familiarity that caused little differentiation in participant’s assignment of liability between manufacturer and driver. This suggests the need to simplify investigation of incidents with more targeted questions: How can we determine the exact cause of accidents, and how do we provide that evidence? Since manual driving is still a desired activity according to our in-depth interview responses, a potential incentive toward broader AV adoption may be that vehicles begin to make decisions more reliably and safely than humans, and that liability for accidents can be attributed to the manufacturer accurately and when appropriate (Shabanpour, et. al, 2018).

Our participants’ responses also provided implication that severity of the accident did not lead them to treat the driver as any less liable, indicating there might not be a need to treat injured parties or accident severity in any favored way when it comes to compensation for accidents (Swierczynski & Żarnowiec, 2020). As more people own vehicles with semi-autonomous features and utilize them, there are likely to be more documented legal outcomes of accidents that can be studied as precedent, which may yield different results as a more solid public opinion of autonomous liability is formed, especially as higher levels of automation come into common use simultaneously.

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APPENDIX A: BACKGROUND RESEARCH

As an outcome of the fatal accident on March 2019, Tesla was charged for the following: their Autopilot system allowed the Tesla driver to avoid paying attention, Autopilot wasn't designed to work in areas with cross traffic, and yet

Tesla allows drivers to use it under those circumstances and failure to limit where autopilot can be used (National Transportation Safety Board, 2019). This serves as an example of liability being assigned to the manufacturer based on safety deficiencies in their ADAS product.

OEMs are responding to the demand for automation in vehicles. NHTSA has officially requested data to safely develop Automated Driving Systems (ADS). “The Agency is seeking to draw upon existing Federal and non-Federal foundational efforts and tools in structuring the framework as ADS continue to develop. NHTSA seeks specific feedback on key components that can meet the need for motor vehicle safety while enabling innovative designs, in a manner consistent with agency authorities” (NHTSA & DOT, 2020).

Partners in Europe from government, industry, and academia are currently working to collect data on AV interaction in mixed traffic through a project known as “interACT”. The objective is to ultimately provide and improve the research, the methods, the development and the designs to safely integrate AVs into the traffic environment. Sections of this study include exploratory interviews with experts regarding ethics, legislation, and adoption of autonomous vehicles (Dietrich, et. al, 2020).

APPENDIX B: FIGURES

Figure 8

Participant Gender and Age Group Demographics

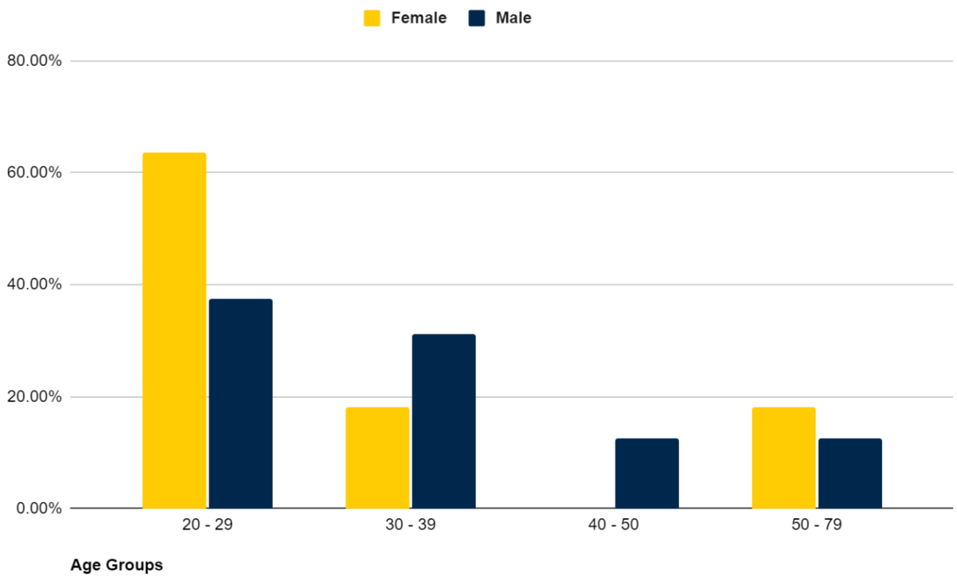


Figure 9

Variance of Industry and Combined Familiarity Score

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
LAW - AUTO	-1.455	0.514	(-2.724, -0.185)	-2.83	0.022
OTR - AUTO	-0.636	0.514	(-1.905, 0.633)	-1.24	0.441
OTR - LAW	0.818	0.514	(-0.451, 2.087)	1.59	0.265

Individual confidence level = 98.05%

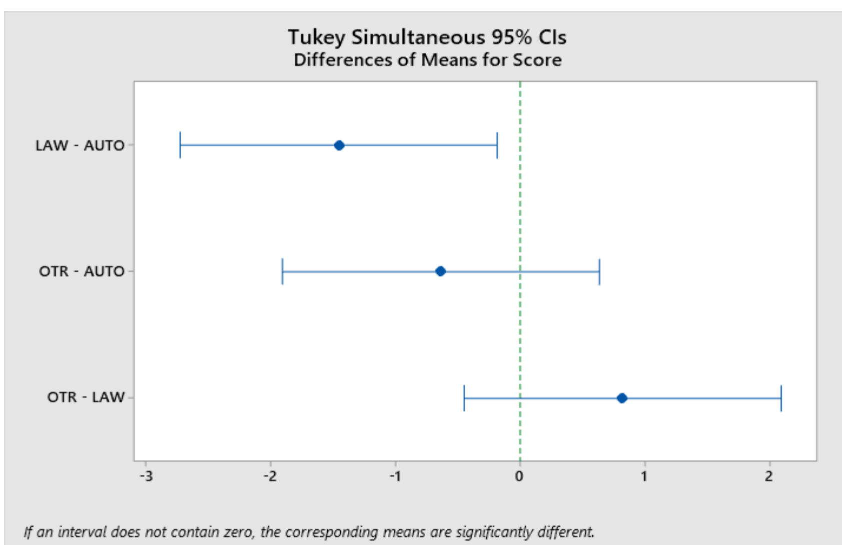


Figure 10

Scenario 1 Liability Attribution by Industry

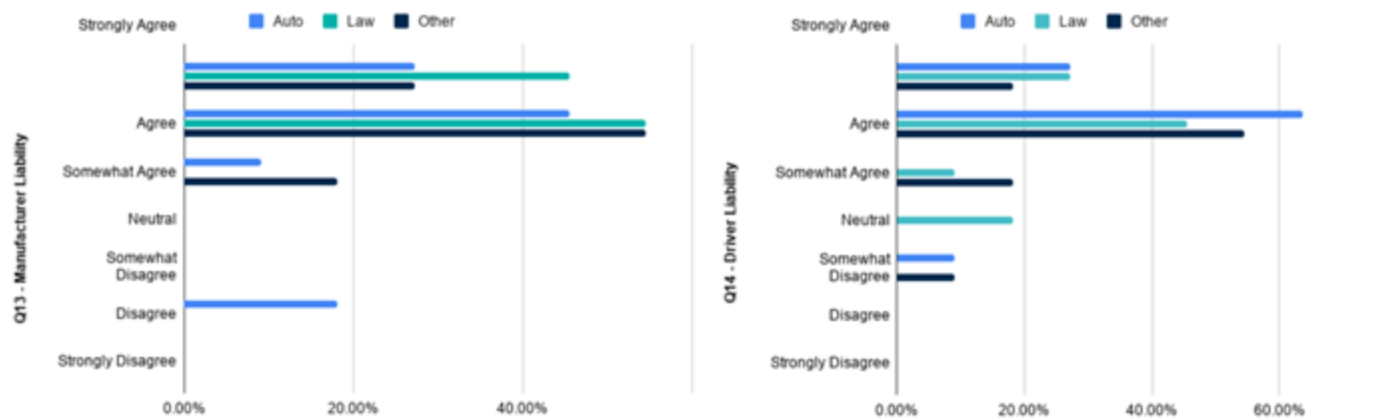


Figure 11

Scenario 2 Liability Attribution by Industry

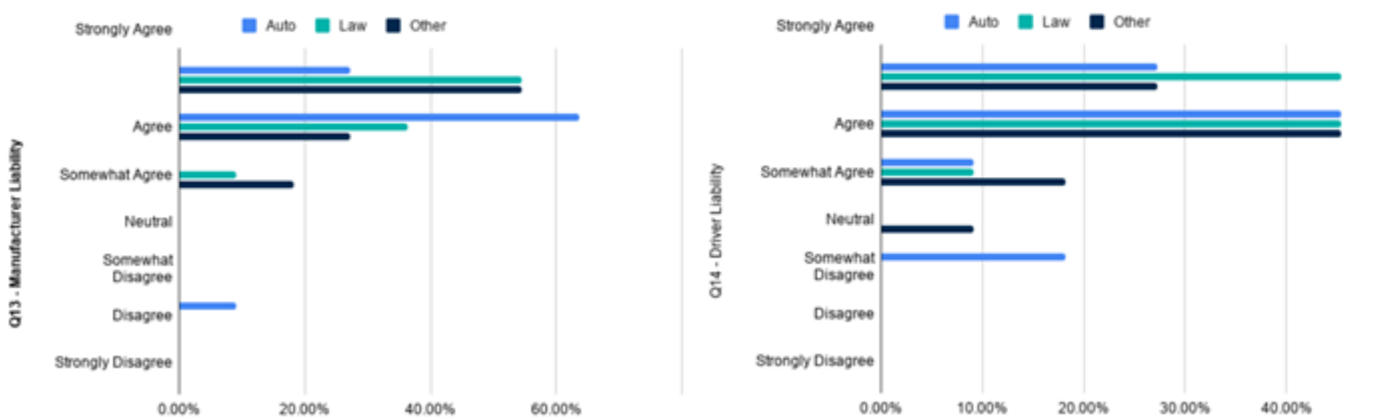


Figure 12

Scenario 3 Liability Attribution by Industry

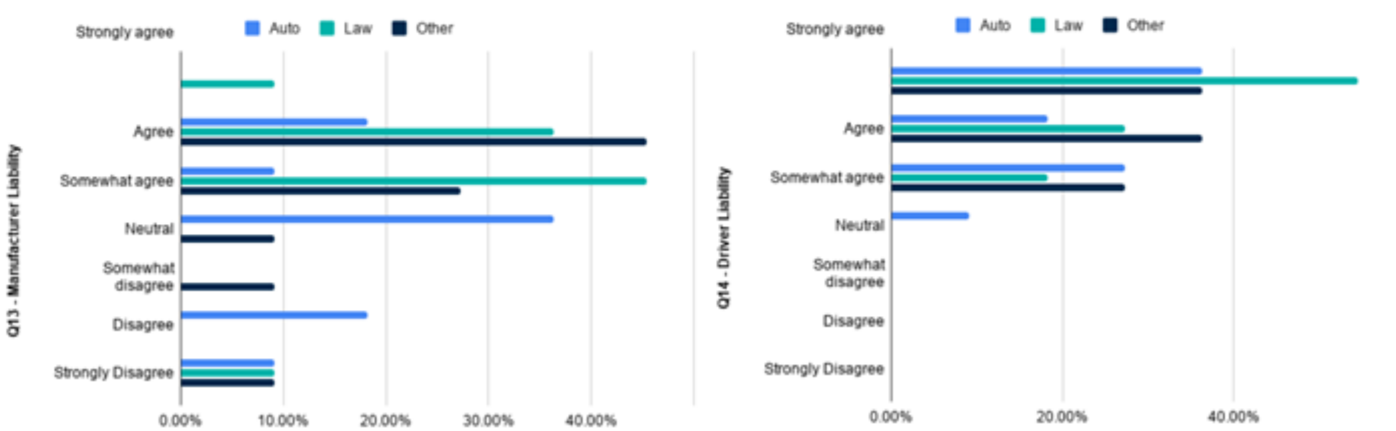
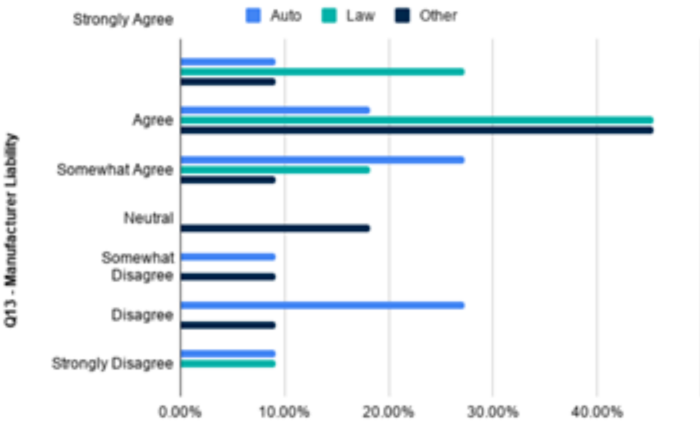
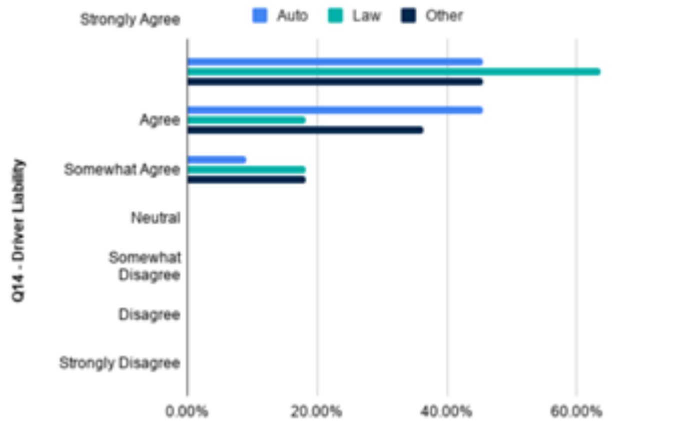


Figure 13

Scenario 4 Liability Attribution by Industry





APPENDIX C: DATA ANALYSIS TABLES

Table 1

Means, Standard Deviations, and One-Way ANOVA Analyses of Variance in Participant Industry and Combined Familiarity Score

Measure	Familiarity Score[a]					
INDUSTRY	N	Mean	StDev	95% CI	F-Value	P-Value
AUTO	11	7.364	0.674	(6.621, 8.106)	4.02	0.028*
LAW	11	5.909	1.221	(5.166, 6.652)		
OTR	11	6.727	1.555	(5.985, 7.470)		
Pooled StDev = 1.20605						

[a] Numeric results of Q7, Q8, and Q9 combined to achieve the familiarity score.

* P=0.028 where <0.05 is significant.

Table 2

Summary of Response Mean Values from Scenarios 1 -4

Scenario 1

Statistics

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
How liable is the manufacturer	33	0	6.000	0.209	1.199	2.000	6.000	6.000	7.000
How liable is the driver in thi	33	0	5.848	0.185	1.064	3.000	6.000	6.000	6.500
How severe do you perceive the	33	0	5.697	0.211	1.212	2.000	5.000	6.000	7.000
How much does the severity of t	33	0	5.303	0.228	1.311	1.000	4.000	5.000	6.000

Variable	Maximum
How liable is the manufacturer	7.000
How liable is the driver in thi	7.000
How severe do you perceive the	7.000
How much does the severity of t	7.000

Scenario 2

Statistics

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
How liable is the manufacturer	33	0	6.242	0.174	1.001	2.000	6.000	6.000	7.000
How liable is the driver in thi	33	0	5.970	0.187	1.075	3.000	6.000	6.000	7.000
How severe do you perceive the	33	0	6.727	0.117	0.674	4.000	7.000	7.000	7.000
How much does the severity of t	33	0	5.636	0.245	1.410	1.000	4.500	6.000	7.000

Variable	Maximum
How liable is the manufacturer	7.000
How liable is the driver in thi	7.000
How severe do you perceive the	7.000
How much does the severity of t	7.000

<u>Scenario 3</u>

Statistics

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
How liable is the manufacturer	33	0	4.515	0.305	1.752	1.000	4.000	5.000	6.000
How liable is the driver in thi	33	0	6.152	0.158	0.906	4.000	5.000	6.000	7.000
How severe do you perceive the	33	0	4.455	0.295	1.697	1.000	3.000	4.000	6.000
How much does the severity of t	33	0	4.697	0.280	1.610	1.000	4.000	4.000	6.000

Variable	Maximum
How liable is the manufacturer	7.000
How liable is the driver in thi	7.000
How severe do you perceive the	7.000
How much does the severity of t	7.000

<u>Scenario 4</u>

Statistics

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
How liable is the manufacturer	33	0	4.879	0.322	1.850	1.000	3.500	6.000	6.000
How liable is the driver in thi	33	0	6.364	0.129	0.742	5.000	6.000	7.000	7.000
How severe do you perceive the	33	0	6.727	0.117	0.674	4.000	7.000	7.000	7.000
How much does the severity of t	33	0	5.485	0.239	1.372	1.000	4.000	6.000	6.500

Variable	Maximum
How liable is the manufacturer	7.000
How liable is the driver in thi	7.000
How severe do you perceive the	7.000
How much does the severity of t	7.000

Table 3

Sentiment Analysis - Scenarios 1 and 2

Word	Length	Count	Weighted Percentage	Similar Words
disappointment	14	9	4.84%	disappointed, disappointment
frustrated	10	7	3.76%	frustrated, frustration
annoyed	7	6	3.23%	annoyance, annoyed
anger	5	5	2.69%	anger
angry	5	5	2.69%	angry

Word	Length	Count	Weighted Percentage	Similar Words
disappointment	14	8	4.10%	disappointed, disappointment
sad	3	8	4.10%	sad, sadness
anger	5	7	3.59%	anger
concerned	9	7	3.59%	concern, concerned
frustrated	10	6	3.08%	frustrated, frustration

Table 4

Sentiment Analysis - Scenarios 3 and 4

Word	Length	Count	Weighted Percentage	Similar Words
disappointment	14	8	4.23%	disappointed, disappointment
sad	3	7	3.70%	sad, sadness
confused	8	6	3.17%	confused, confusion
angry	5	5	2.65%	angry
concerned	9	4	2.12%	concerned

Word	Length	Count	Weighted Percentage	Similar Words
disappointment	14	10	4.85%	disappointed, disappointment
frustrated	10	8	3.88%	frustrated, frustration
sad	3	7	3.40%	sad, sadness
anger	5	6	2.91%	anger
vehicle	7	6	2.91%	vehicle

Table 5

All Scenarios Sentiment Analysis

Word	Length	Count	Weighted Percentage
disappointment	14	24	3.09%
anger	5	21	2.71%
sad	3	19	2.45%
angry	5	18	2.32%
frustrated	10	16	2.06%
concerned	9	14	1.80%
annoyed	7	13	1.68%
driver	6	12	1.55%
none	4	12	1.55%
disappointed	12	11	1.42%

APPENDIX D: INTERVIEW QUESTIONS

In-Depth Interview Questions

Context:

In this study, all references to semi-autonomous vehicles imply an autonomy level of 3 according to SAE levels of driving automation. This means the semi-autonomous vehicle will drive itself when automated driving features are engaged. However, an effective driver monitor system is required to ensure driver ability to take over when required (take-over request). The driver can also resume control of the vehicle from autonomous mode at any time.

Part 1: Familiarity

1. Have you ever heard of an "autonomous vehicle" before (e.g., autonomous cars, autonomous shuttle, autonomous bus, etc.)? If so have you ever taken a ride in one before?

2. Could you describe how you feel towards self-driving vehicles?

3. Briefly describe how you think you will operate a semi-autonomous vehicle?

4. Tell me about your view on liability and semi-autonomous vehicles?

Part 2: Scenario Specific

Scenario 1: A semi-autonomous vehicle is driving up to an intersection. The automated driving system does not send a take−over request. The semi-autonomous vehicle crashes into another vehicle in the intersection, causing minor injuries and damage to both parties.

1. How do you feel about this situation?

2. Was there anything unexpected about this situation?

3. How do you think liability should be allocated?

4. Which feelings do you have towards the AV, the driver, the manufacturer?

5. What do you think could have been done better?

Scenario 2: A semi-autonomous vehicle is driving up to an intersection. The automated driving system does not send a take−over request. The vehicle fails to stop where indicated by a stop sign and crashes into another vehicle, killing the other vehicle's driver

1. How do you feel about this situation?

2. Was there anything unexpected about this situation?

3. How do you think liability should be allocated?

4. Which feelings do you have towards the AV, the driver, the manufacturer?

5. What do you think could have been done better?

Scenario 3: A semi-autonomous vehicle is driving up to an intersection. The automated driving system sends a take−over request. The driver takes control of the vehicle immediately to avoid hitting a pedestrian in a crosswalk. The semi-autonomous vehicle crashes into another vehicle in the intersection, causing minor injuries and damage to both parties.

1. How do you feel about this situation?
2. Was there anything unexpected about this situation?
3. How do you think liability should be allocated?
4. Which feelings do you have towards the AV, the driver, the manufacturer?
5. What do you think could have been done better?

Scenario 4: A semi-autonomous vehicle is driving up to an intersection. The automated driving system sends a take−over request. The driver takes control immediately of the vehicle to avoid hitting a pedestrian in a crosswalk. The semi-autonomous vehicle crashes into another vehicle in the intersection, killing that other vehicle's driver.

1. How do you feel about this situation?
2. Was there anything unexpected about this situation?
3. How do you think liability should be allocated?
4. Which feelings do you have towards the AV, the driver, the manufacturer?
5. What do you think could have been done better?