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TECHNICAL REPORT

Mapping Comprehension of ADAS across Different Road Users

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Title

Mapping Comprehension of ADAS across Different Road Users

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Foreword

New and sophisticated vehicle technology is beginning to change the nature of driving, assuming tasks that were previously part of the driver's responsibility. Past research has documented critical gaps in drivers' understanding of these technologies and related safety implications. However, less is known about how understanding of new technology varies across the driving population. Moreover, the emergence of a troubling group of drivers—those with poor or limited knowledge of vehicle technology but *think* that their understanding is accurate—begs further research.

This technical report summarizes a survey study examining how the understanding of advanced driver assistance systems varies as a function of driver demographics and other experiences. Also, the report endeavors to shed insight into the highly confident but less knowledgeable sub-group of drivers. The results should be informative to researchers, the automobile industry, and government entities.

This report is a product of a cooperative research program between the AAA Foundation for Traffic Safety and the SAFER-SIM University Transportation Center.

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About the Sponsors

AAA Foundation for Traffic Safety
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Founded in 1947, the AAA Foundation for Traffic Safety in Washington, D.C., is a nonprofit, publicly supported charitable research and educational organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, individual members, AAA-affiliated insurance companies, and other organizations or sources.

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SAFER-SIM is comprised of a multidisciplinary, synergistic team of researchers in human factors, engineering, computer science, and psychology who will use innovative simulation approaches ranging from microsimulation to human-in-the-loop simulation to promote safety. SAFER-SIM sponsors research and outreach activities in STEM areas, and aids workforce development efforts in transportation safety.

The universities comprising SAFER-SIM study how road users, roadway infrastructure, and new vehicle technologies interact and interface with each other using microsimulation and state-of-the-art driving, bicycling, and pedestrian simulators.

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Executive Summary

Studies have documented gaps in drivers' understanding of advanced driver assistance systems (ADAS); however, there have been few attempts to map knowledge of vehicle technology across different driver characteristics, experiences, and perceptions. Other studies have identified groups of drivers who differ in their knowledge of technology as well as their confidence in their knowledge, including drivers who were lacking in knowledge, but also highly confident. The aims of the current study are as follows:

1. Explore the impact of technology proficiency, confidence, ADAS ownership, personal characteristics and demographics, on drivers' mental models of adaptive cruise control (ACC) and lane keeping assist (LKA).
2. Identify and characterize clusters of drivers based on results from the quality of their mental model of ADAS and their confidence in said knowledge.

The current study employed a national online survey that examined experiences with ADAS, learning preferences, and driving habits from 2,528 participants based on age, race, and gender. Road users' understanding of ACC and LKA were evaluated using mental model assessments. Four distinct clusters (Weak Confident, Strong Confident, Weak Unconfident, Strong Unconfident) of road users emerged, based on road users' mental models as well as confidence in their mental models revealing some important patterns pertaining to their consumer education preferences, use of ACC and LKA, and driving self-efficacy. Findings suggest that road users with a strong understanding of ADAS are younger and preferred relying on videos and the internet to find educational material compared to learning about vehicle systems from the owner's manual or by trial and error. Road users in the strong confident and weak confident clusters reported driving safer and had more positive perceptions of technology. They also reported higher levels of familiarity, trust, and ownership of ACC and LKA systems compared to the strong unconfident and weak unconfident clusters. While experience can aid drivers' understanding about the systems, it may not necessarily lead to sufficient and accurate assessment on how the U.S. population is using ADAS. The current results also underscore the importance of targeted education about vehicle technology.

Introduction

The primary purpose of advanced driver assistance systems (ADAS) is to provide increased safety to drivers and other road users. Even if ADAS is available in their vehicles, drivers may not use these features to their full extent. Since Adaptive Cruise Control (ACC) and Lane Keeping Assistance (LKA) are widely available, it is important to recognize road users' understanding and knowledge (i.e., mental models) of this technology and their preferences for learning about these systems. Road users' mental models and confidence in their mental models provide a critical insight into if and how they will use ADAS.

A mental model has been defined as a reflection of an operator's knowledge of a system's purpose, its form and function, and its observed and future system states (Seppelt & Victor, 2020). It follows that an operator's mental model can have important implications in determining how they interact with a given system. An incorrect mental model can negatively impact both the potential safety benefits that are intended by the system and overall road safety. For example, Gaspar et al. (2021) found that drivers who had poor mental models of ACC were less likely to react or slower to react to certain situations where the technology did not function compared with drivers who had strong mental models. A number of studies have documented gaps in drivers' understanding of vehicle technology (e.g., McDonald et al., 2018; Jenness et al., 2008); however, there have been fewer attempts to map knowledge of vehicle technology across different driver characteristics, experiences, and perceptions. As such, this study explores the impact of technology proficiency, confidence, ADAS ownership, personal characteristics, and demographics on drivers' mental models of ACC and LKA, using a sample representative of the U.S. population for age, sex, and race.

Mental models are based on the road user's beliefs and perceptions and may be derived from various educational sources (e.g., a demonstration at the dealership, information on the internet, or the owner's manual). Road users do not necessarily rely on educational material, and often adjust their mental model based on using or interacting with the ADAS. However, trial-and-error is likely not sufficient for forming mental models that align with ADAS capabilities and limitations (cf. Carney et al., 2022). As technology becomes more sophisticated and complex (e.g., increasing levels of automation), more challenges with the formation of well-calibrated mental models are anticipated. The current study also aims to examine how drivers' understanding of technology is impacted or shaped by their preferences and experiences concerning different approaches to learning about ADAS.

In a recent study, Carney and colleagues (2022) explored longitudinal and experiential trends on new owners' mental models of ADAS in a naturalistic setting. They further identified different clusters of drivers defined not only by their actual understanding (i.e., mental model strength) of ACC, but also by their confidence in that level of understanding (Lenneman et al. (2020) also found similar clusters of drivers). For example, some drivers had strong knowledge of ACC and also had high confidence in this knowledge; others had weaker knowledge but also recognized this, based on their confidence assessment. The emergence of different groups of drivers carries important implications for safety, especially given the unsettling emergence of a group of drivers who were lacking in knowledge, but highly confident that their knowledge was strong. Such drivers might be more prone to mishandling or inappropriate use of automation. While these groups have been identified in past studies, the qualities and characteristics of the different groups are still relatively unknown, along with information regarding their preferred learning approaches. Thus, the current study also aims to identify and characterize clusters of drivers based on results from the quality of their mental model of ADAS and their confidence in said knowledge. Understanding these different clusters may help inform targeted approaches aimed at better aligning or calibrating confidence and actual knowledge (Horrey et al., 2015).

Thus, this study had two major aims:

1. Characterize road users with a weak understanding of ADAS compared to those with a strong understanding of ADAS along different dimensions, including demographics, experiences, perceptions regarding vehicle technology, and attitudes and preferences towards education, among others.

2. Identify clusters of drivers based on results from the quality of their mental model of ADAS and their confidence, and to explore factors that distinguish these clusters.

Method

An online survey was employed for the current study with a sample of road users representative of the U.S. population. The first aim of this study was to compare road users with a weak understanding of ADAS (ACC and LKA) to road users with a strong understanding of ADAS. This was done by splitting the road users into quartiles based on ADAS understanding and comparing the characteristics of the first quartile (weak understanding) with those of the fourth quartile (strong understanding). The second aim of this study was to classify road users based on the strength of their mental model of ACC and LKA (i.e., lane keeping and lane centering systems), as well as their confidence in their understanding. To do this, mental model assessment survey responses were aggregated and entered into a cluster analysis. Clusters were then compared along a number of different dimensions.

Survey Instrument

The survey was created in Qualtrics and administered via computer, tablet, or mobile device. The research team developed a survey from previous surveys with minor modifications (Gaspar et al., 2021; Mason et al., 2021; McDonald et al., 2018; AAAFTS, 2022). Where possible, the survey retained original question wording from the source surveys; any wording changes made were intended to ensure clarity, consistency, and readability for survey participants, as well as adherence to guidance from the University of Iowa Institutional Review Board. The survey itself contained a waiver of consent and the following four sections:

1. Demographics and Driving Experience – 26 questions
2. Experience with Advanced Driver Assistance Systems – 33 questions
3. Learning about Advanced Driver Assistance Systems – 5 questions
4. Perceptions of Technology and Driving – 26 questions

Each section contained a brief description and any relevant definitions. The complete survey is included in Appendix A.

Demographics and Driving Experience

Outcome variables extracted from these items included the following:

- Age, sex, race, and ethnicity
- Driving status and habits (days spent driving per week)
- Driving self-efficacy (i.e., confidence in their driving abilities during specific situations; score was aggregated from six survey items: Q20.1–Q20.5 & Q21.2; see Appendix A)
- Driving safety
- Experience with ACC and LKA

Experience with Advanced Driver Assistance Systems

Outcome variables extracted from these items pertained to ACC or LKA and included familiarity, trust, ownership, use, understanding, and confidence in their understanding.

Mental Model Assessment

The mental model assessment (Gaspar et al., 2021) asked questions about the participants' understanding of ACC and LKA. The LKA mental model assessment items were developed for this study and the ACC items were selected from the previous mental model assessments for ACC (Gaspar et al., 2021). The assessment was comprised of 19 true/false questions that evaluated a driver's understanding of specific functions and limitations of ACC (12 questions) and LKA (7 questions). For each of the true/false questions, participants were asked to rate their confidence in their response on a 4-point scale (1-no confidence, 2-slight confidence, 3-moderate confidence, or 4-high confidence). Each true/false and confidence item were aggregated into a total score and calculated as a percentage ranging from 0 (all items incorrect) to 100% (all items correct) and 0% (no confidence) to 100% (complete confidence). Table 1 includes the mental model assessment survey items for ACC and LKA. Two items (shown in italics) were later identified as ambiguous and could be argued as being true or false and thus were removed from the analysis.

Table 1. Mental Model Assessment Items.

The statement about ACC is…
Maintains the speed that you have set when there are no vehicles detected in the lane ahead (T)
Will accelerate if a slower vehicle ahead moves out of the detection zone (T)
Will provide steering input to keep the vehicle in its lane (F)
Will correctly detect motorcycles and other smaller vehicles not driving in the center of the lane (F)
May not correctly detect stopped vehicles in your lane (T)
Reacts to stationary objects on the road (construction cone, tire, ball) (F)
Works well on curvy roads and hills (F)
Adjusts the speed when there are slower moving vehicles detected ahead (T)
Will react immediately to vehicles merging onto the road in front of you (F)
Is meant to be used on rural roads (F)
May not correctly detect vehicles ahead traveling at much slower speeds (F)
Can handle operating in all weather conditions (F)
The statement about LKA is…
LKA will provide steering input to keep the vehicle in its lane (T)
LKA can operate in all weather conditions (F)
LKA will drive where lane lines are faded (F)
LKA works on curvy roads (F)
LKA can drive in a work zone where lanes have shifted from their usual location (F)
LKA can work with direct sun glare ahead (T)
LKA will change lanes to pass a slower moving vehicle ahead (F)

Note: Participants provided true or false responses and rated confidence in their response on 4-point scale. Correct responses are shown in parentheses.

Learning about Advanced Driver Assistance Systems

Outcome variables included how participants learned about the ADAS in their vehicle, preferred methods/mediums of learning about ADAS, confidence in their ability to find information pertinent to ADAS, and importance of understanding ADAS.

Perceptions of Technology

Outcome variables included 10 items pertaining to users' perceptions of technology as well as 16 items related to different risky driving behaviors.

Survey Administration

The target sample size of this study was 2,500 road users that were representative of the U.S. population based on age, sex, and race. An address-based sample was purchased from Dynata and 36,719 invitation letters were mailed to adults in the U.S. The initial wave resulted in a sample size of 437 (≈ 1% response rate) and so Prolific was used as a secondary sampling approach. On the Prolific platform, 2,311 participants agreed to take the survey and 2,199 (≈ 95% response rate) completed the survey. The survey was hosted on Prolific for ten days.

Respondents who accessed the link or QR code were first presented with a statement of informed consent. Only respondents who agreed could proceed to the survey. Participants were then screened for eligibility. They were required to be 18 years or older and able to read English. None of the survey items required a response (i.e., forced answering). Forced answering has been shown to increase state reactance (i.e., anger and negative cognitions), increase questionnaire dropout, and reduce data quality (Sischka et al., 2022). The survey was considered completed if the respondent reached the final screen and responded to >90% of the survey items. Participants were compensated $5 after completing the survey. This study was completed with approval from the University of Iowa Institutional Review Board (IRB202212393). All analyses were conducted with R (R Core Team, 2023) in the tidyverse ecosystem.

Results

Sample Characteristics

Of the 2,775 respondents that agreed to participate, 233 did not complete the survey and 13 were removed because they completed the survey in less than 4 minutes. After removing these respondents, the final sample consisted of 2,529 adults between 18 and 93 years old (Table 2). A majority of the survey respondents were male (51%), white (76%), had obtained a college degree (69%), and reported driving at least once a week

(96%). Average time to complete the survey was approximately 13 minutes (Mean = 13.25 min, SD = 8.5). Data collection took place between February and April 2023. Participants responses were collected from all US states (including AK and HI), Puerto Rico, and Washington DC (Figure 1).

Table 2. Road user's demographics, driving frequency, and primary mode of transportation.

Variable	Sex		Total Sample (N=2529)
	Male (n=1299)	Female (n=1206)	
Mean Age, in years (SD)	46.1 (16.2)	45.9 (15.5)	45.9 (15.9)
Race and Ethnicity			
American Indian or Alaska Native	4 (<1%)	2 (<1%)	6 (<1%)
Asian/Asian American	64 (5%)	62 (5%)	128 (5%)
Black/African American	136 (10%)	155 (13%)	292 (12%)
Hispanic, Latino, or Spanish origin	66 (5%)	49 (4%)	115 (5%)
White	1000 (77%)	917 (76%)	1929 (76%)
Other	18 (1%)	13 (1%)	32 (1%)
Prefer not to answer	11 (1%)	8 (<1%)	26 (1%)
Education			
Did not complete HS	9 (<1%)	4 (<1%)	14 (1%)
HS or GED	138 (11%)	134 (11%)	273 (11%)
Some College	257 (20%)	276 (23%)	536 (21%)
AA	124 (10%)	159 (13%)	287 (11%)
BS	506 (39%)	442 (37%)	960 (38%)
Graduate degree	263 (20%)	191 (16%)	456 (18%)
Driving Frequency			
Never driven	23 (2%)	15 (1%)	40 (2%)
Driving cessation	33 (3%)	32 (3%)	66 (3%)
<3 days/wk	759 (58%)	596 (49%)	1364 (54%)
3-4 days/wk	251 (19%)	289 (24%)	544 (22%)
≥5 days/wk	232 (18%)	274 (23%)	513 (20%)
Primary Mode of Transportation			
Drive myself	1110 (85%)	991 (82%)	2119 (84%)
Ride with others	85 (7%)	138 (11%)	225 (9%)
Bicycle	9 (<1%)	6 (<1%)	15 (<1%)
Motorcycle/Moped	3 (<1%)	1 (<1%)	5 (<1%)
Public transportation	37 (3%)	31 (3%)	70 (3%)
Ride-hailing services	11 (<1%)	13 (1%)	24 (1%)
Walk	44 (3%)	26 (2%)	70 (3%)

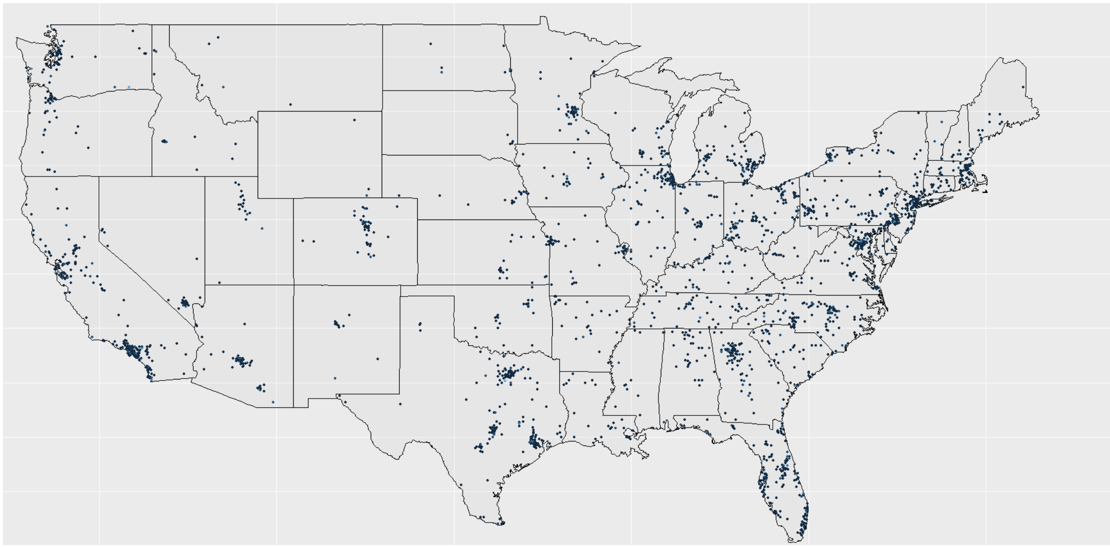

Figure 1. Location of survey respondents across contiguous U.S.

A majority of respondents do not own a vehicle with ACC (62%) or LKA (72%), and a few respondents were not sure if their primary vehicle had ACC (8%) or LKA (7%). Regardless of owning ACC or LKA, road users have some level of familiarity with and understanding of ADAS. Respondents were asked how they learned about the ADAS (Figure 2) and how they would prefer to learn about ADAS (Figure 3). They were able to select multiple methods or modes of education. The methods of learning about ADAS ranged from drivers' education (4%) to trial and error (38%). Owner's manual (37%) was a close second for contributing to road users' knowledge of ADAS. Clear differences emerged between how people learn about ADAS and their preferred learning method. Roughly half of road users prefer to learn about ADAS via the owner's manual or videos. An overwhelming majority of road users (67%) preferred to learn about ADAS through trial and error, although only 38% cited this as an actual learning method. The two following sections of this report aim to better understand learning preferences based on road users' mental models of ADAS.

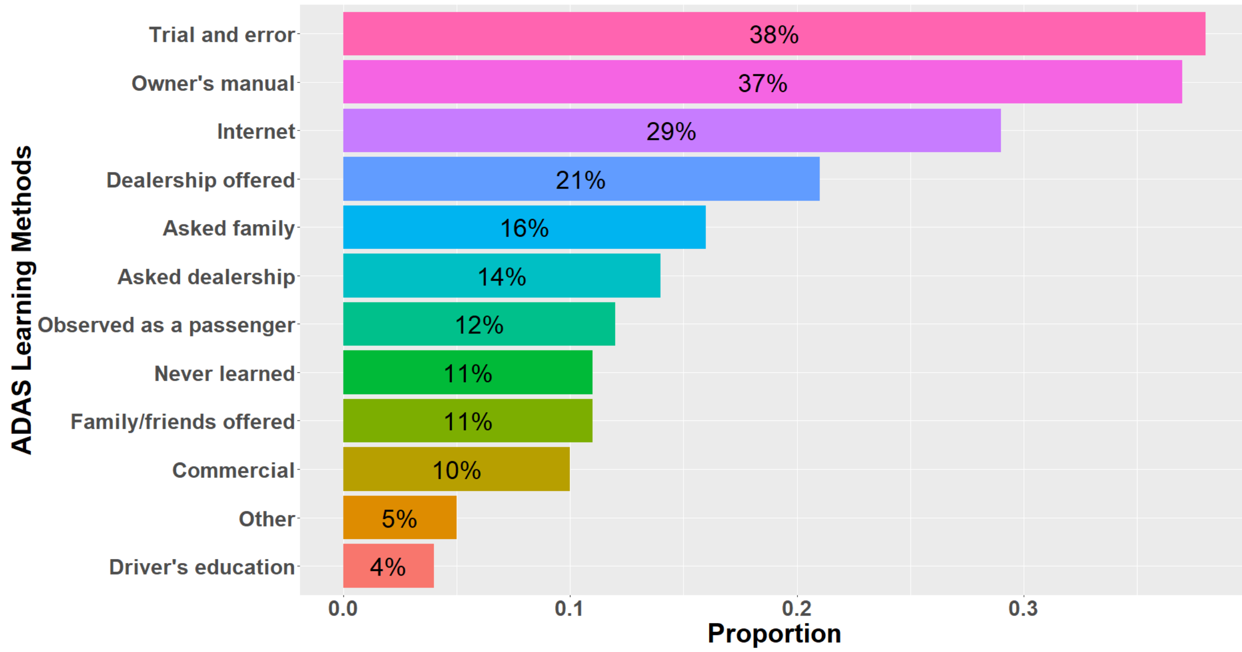

Figure 2. ADAS learning methods for all respondents.

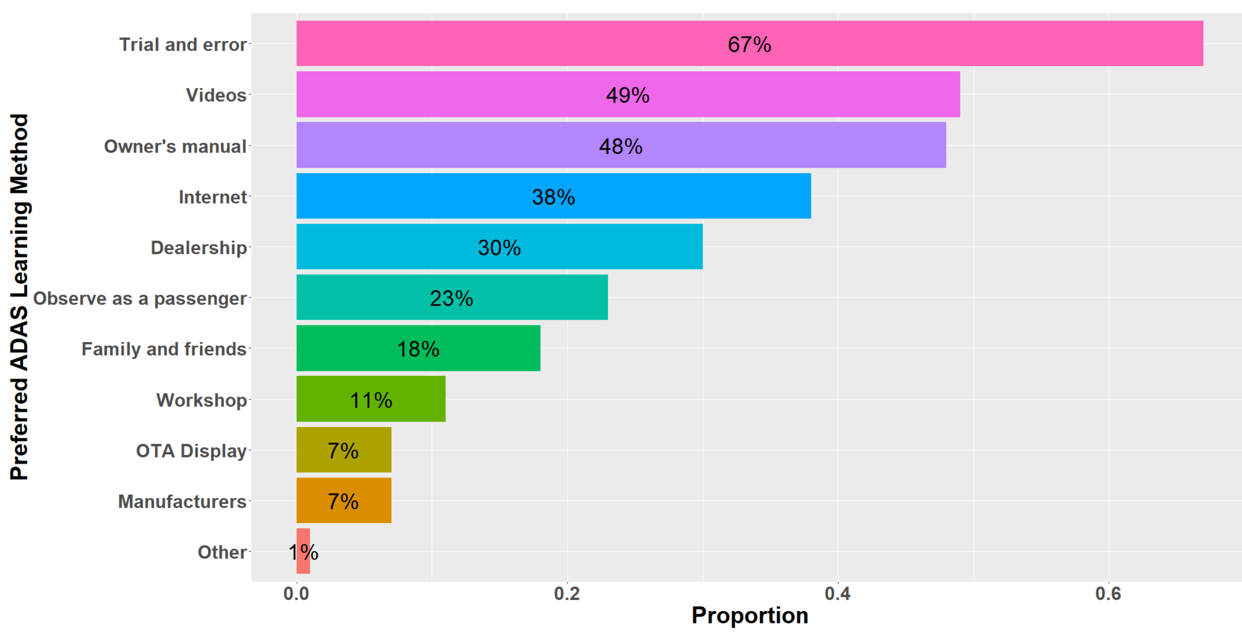

Figure 3. Preferred method to learn about ADAS for all respondents. OTA = over-the-air.

Characteristics of Road Users with Weak versus Strong Understanding of ADAS

To better understand the difference between road users with a strong and weak understanding of ADAS, differences in their demographics, characteristics, and preferences were explored. Scores for ACC and LKA mental model assessments were combined to represent respondents' understanding of ADAS. Road users that scored near or below 50% on the mental model assessment were of particular interest and represented one quarter of the sample. This group was compared to another quarter of the sample representing road users with the strongest understanding. Figure 4 displays the ADAS mental model assessment understanding score between the weak understanding and strong understanding quartiles.

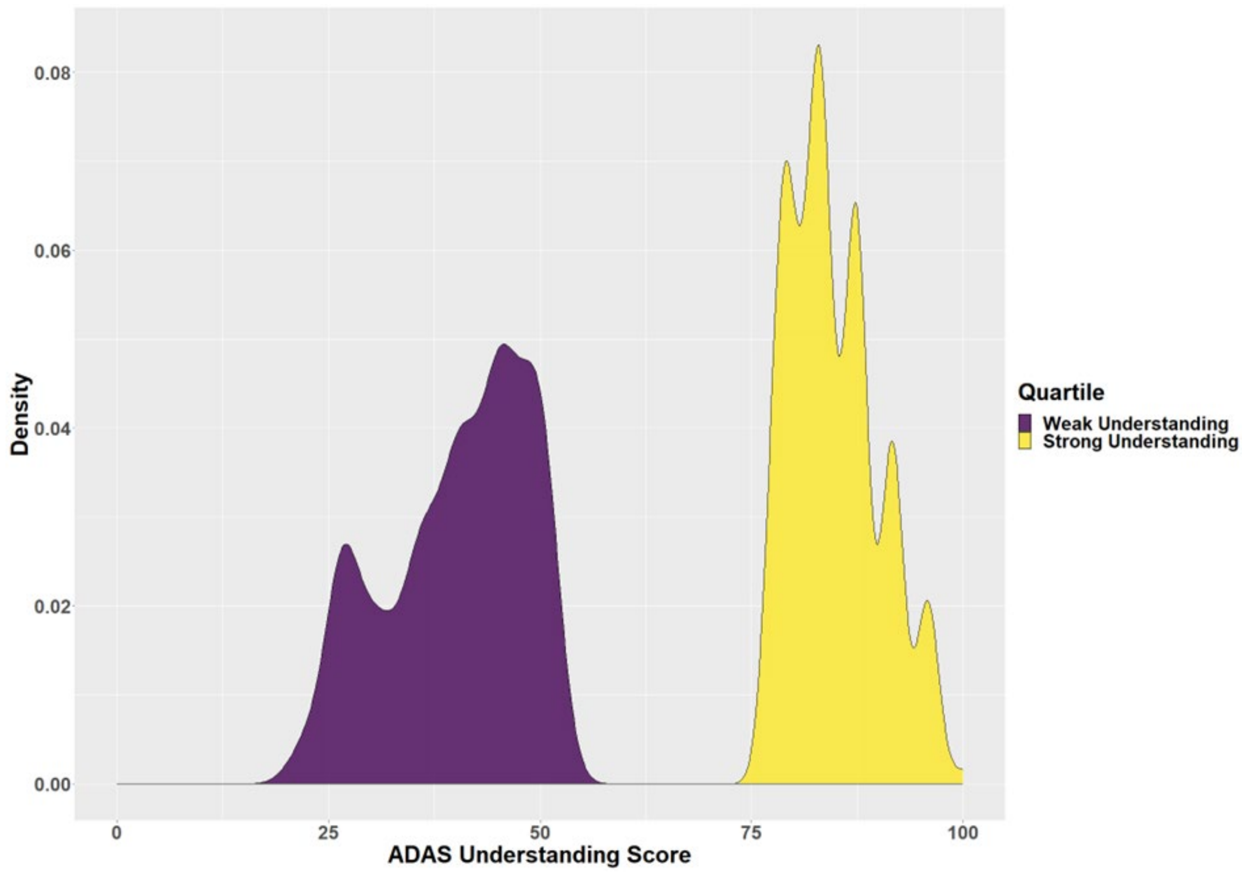

Figure 4. Density Plot of ADAS mental model assessment understanding score for the weak and strong understanding groups.

Road users with a strong understanding of ADAS were on average, 6 years younger than those with a weak understanding (see Table 3). Road users were further characterized to distinguish these two groups. Generally, the groups had similar education levels and a similar proportion of males and females.

Table 3. Road user's demographics and experience and perceptions of ADAS.

Variable	Weak Understanding (n=624)	Strong Understanding (n=626)
Mean Age, in years (SD)	48.7 (15.4)	42.6 (15.2)
Education		
Did not complete HS	3 (<1%)	3 (<1%)
HS or GED	78 (12%)	57 (9%)
Some college	114 (18%)	144 (23%)
AA	79 (13%)	65 (10%)
BS	239 (38%)	232 (37%)
Graduate degree	114 (18%)	124 (20%)
Sex		
Male	330 (53%)	331 (54%)
Female	290 (47%)	283 (46%)
ADAS confidence (0–100)	51.6 ± 22.2	53.2 ± 22.7
Own ACC?		
Yes	204 (33%)	184 (29%)
No	369 (59%)	401 (64%)
Not sure	54 (9%)	40 (6%)
Self-assessed ACC Knowledge (0-10)	4.5 ± 2.8	4.5 ± 3.0
Own LKA?		
Yes	138 (22%)	139 (22%)
No	432 (69%)	454 (73%)
Not sure	57 (9%)	32 (5%)
Self-assessed LKA Knowledge (0–10)	3.9 ± 2.9	3.7 ± 3.0
Importance of Understanding ADAS (1–10)	7.4 ± 3.1	7.5 ± 3.1
Confidence in finding ADAS material (1–10)	7.4 ± 3.0	7.5 ± 2.8

Interestingly, both the strong and weak understanding groups had similar self-ratings of knowledge about both ACC and LKA (ACC: both M = 4.5; LKA: M = 3.7 & 3.9). However, the strong understanding group reported being less familiar and less trusting of ACC and LKA compared to the weak understanding group (Figure 5). The groups also had similar confidence in their ADAS mental model (M = 51.6–53.2) and similar levels of ownership of the systems, although a greater percentage of road users with a weak understanding of ADAS reported not being sure if their vehicle had ACC or LKA (9%) compared to those with a strong understanding (5%–6%). Moreover, the weak understanding group had slightly higher ownership rates for ACC compared to those with a stronger understanding (33% versus 29%). The groups reported similar levels for their confidence in their ability to find educational material for ADAS and both reported that it was important to understand ADAS.

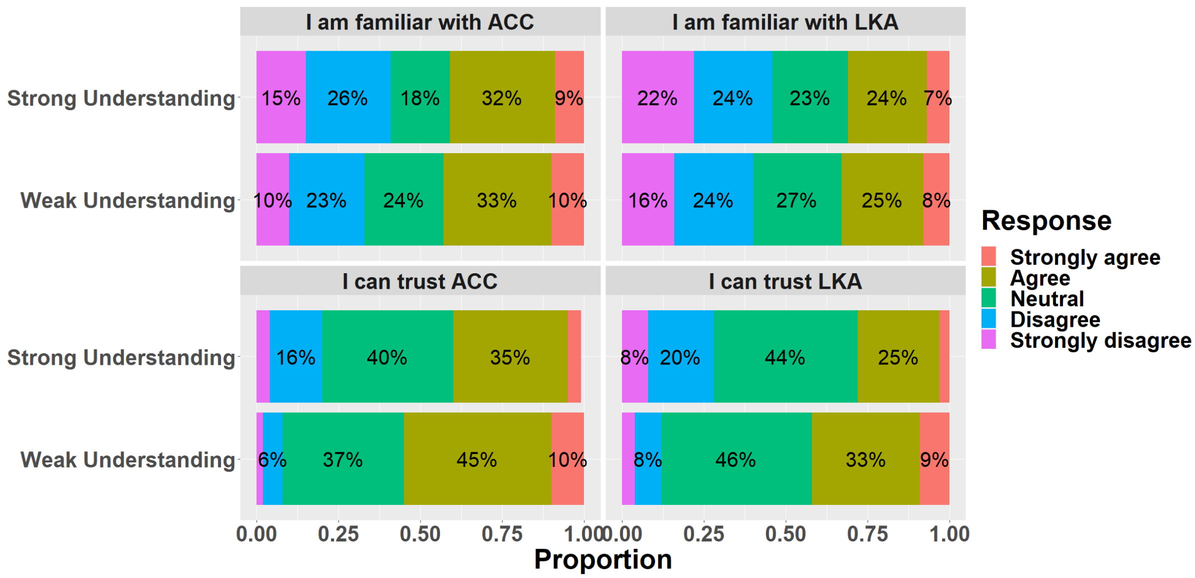

Figure 5. Level of familiarity and trust of ACC and LKA systems between the weak understanding and strong understanding groups.

The strong and weak understanding groups reported using different approaches to learn about ADAS (Figure 6). The strong understanding group reported learning about ADAS through trial and error (45%) whereas the weak understanding group reported relying on the owner's manual (39%) followed by trial and error (30%). Trial and error and the owner's manual were top preferences for both groups.

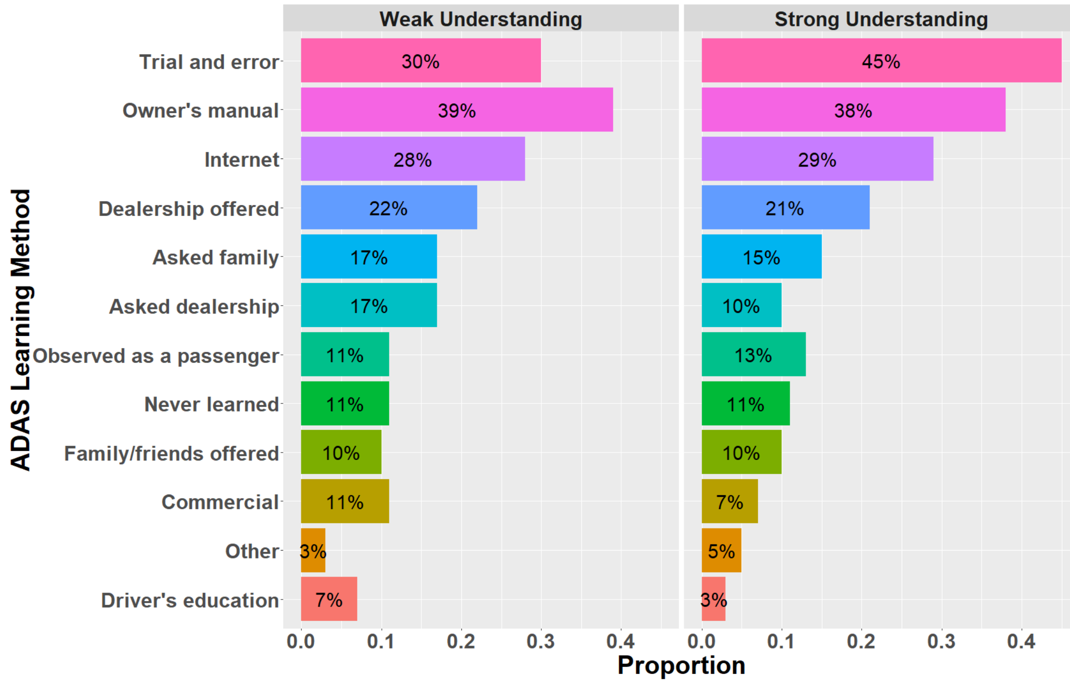

Figure 6. ADAS learning method for the weak understanding and strong understanding groups.

When it came to preferred learning methods, trial and error was a clear preference for both strong (67%) and weak understanding (64%) groups (Figure 7). The strong and weak understanding groups reported similar trends for their preferred approach to learning about ADAS. A greater proportion of the strong understanding group preferred to learn about ADAS via videos and the internet compared to the weak understanding group.

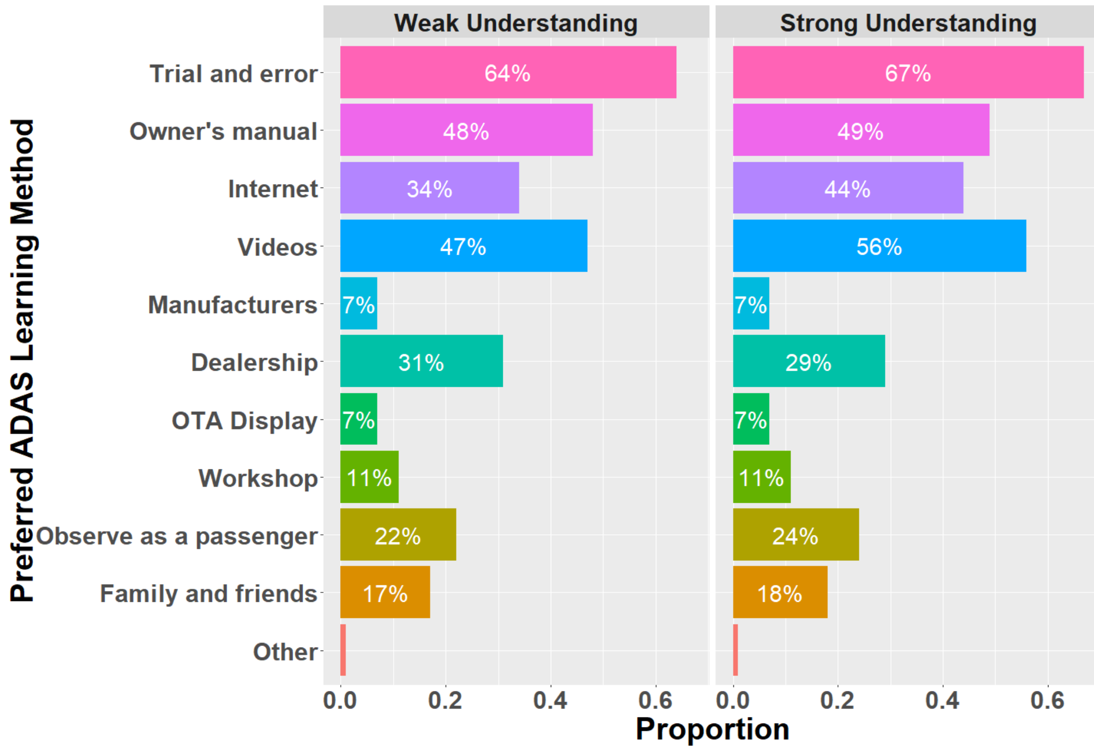

Figure 7. Preferred ADAS education methods between the weak understanding and strong understanding groups. OTA = over-the-air.

To better understand differences in what the two groups know and understand about ACC and LKA, the individual items from the ACC mental model assessment and LKA mental model assessment are displayed in Figure 8 and Figure 9, respectively. Respondents in both groups tended to understand basic functions of ACC (i.e., accelerate if a slower vehicle ahead moves out of the detection zone, maintain speed when no vehicles are detected in the lane ahead, and adjust their speed for slower moving vehicles) but differed on items representing ACC limitations. For example, the weak understanding group reported that ACC could work well on curvy roads and hills, conflated ACC functions with LKA functions (e.g., provides steering input to keep the vehicle in its lane), and believed that ACC was meant to be used on rural roads and in all weather conditions. Similar to ACC, the groups differed in their understanding of LKA. Specifically, the weak understanding group did not understand that LKA may not operate when lane lines are faded or in work zones where lanes have shifted or are unmarked. Nearly half of the road users in the weak understanding group thought that LKA would switch lanes to overtake a slower moving vehicle. These outcomes point to areas where educational approaches can target.

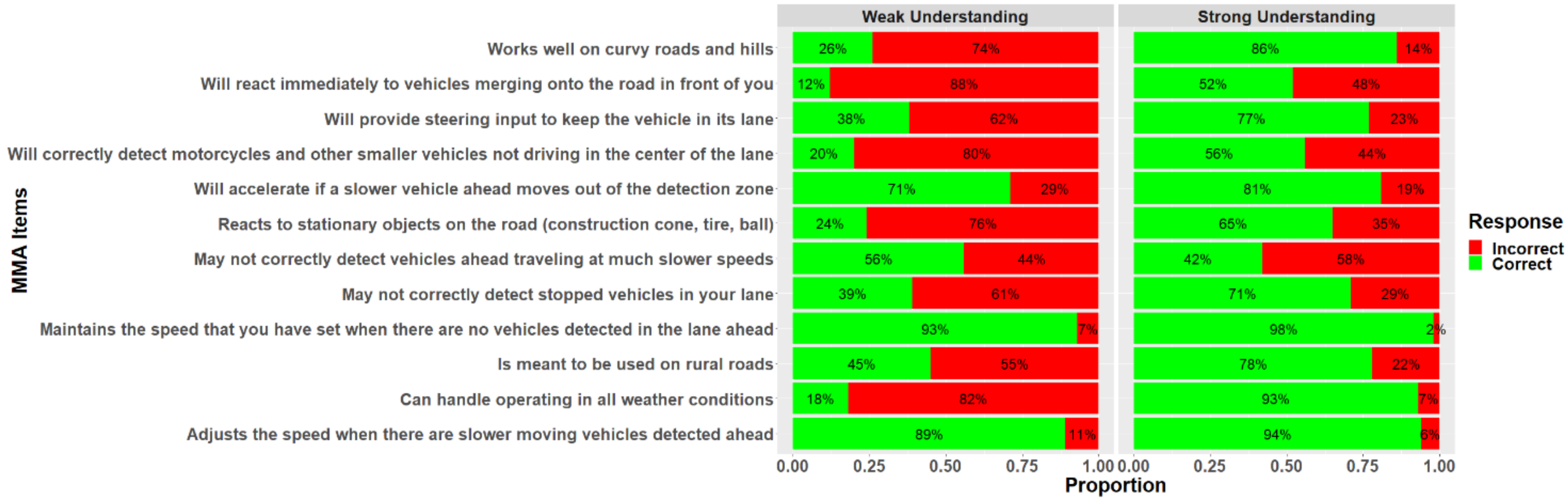

Figure 8. Accuracy on ACC mental model assessment items for the weak and strong understanding groups.

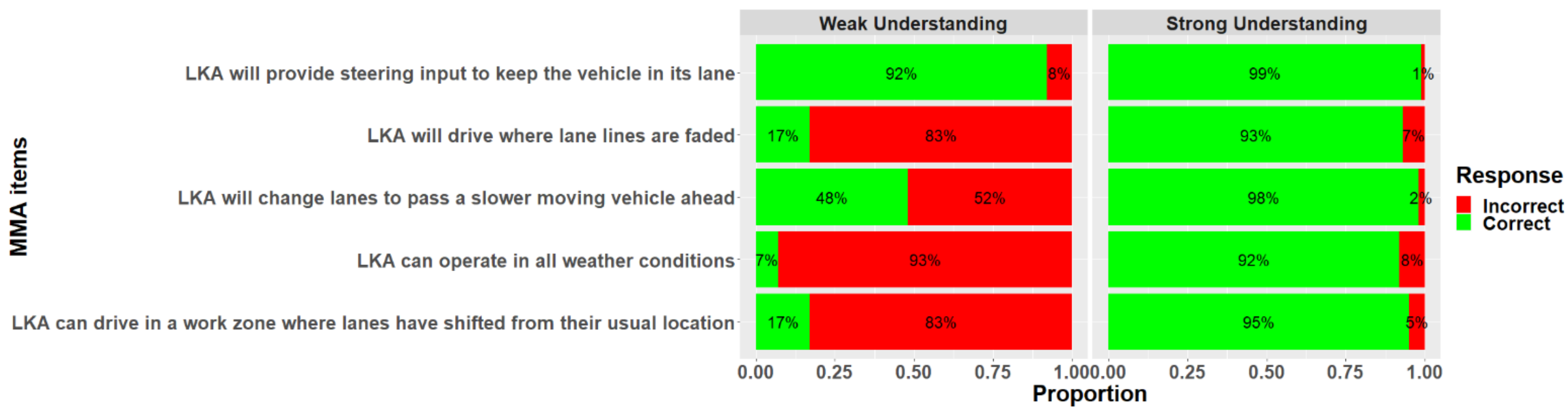

Figure 9. Accuracy on LKA mental model assessment items for the weak and strong understanding groups.

Overall, road users with a strong understanding of ADAS differed from the weak understanding group as they tended to be younger, had decreased trust in ACC and LKA, learned to use ADAS through trial and error, and preferred to learn about ADAS via internet and videos. Interestingly, both groups reported similar levels of familiarity with ADAS, ownership rates of ACC and LKA, and confidence in their mental models of ADAS and their ability to find educational material. The item-level analysis sheds important insights into the areas where the weak group showed the most deficiencies in their knowledge, such as an understanding of specific functional limitations of the technologies. In addition to the analysis and characteristics of the weak and strong knowledge groups, it is necessary to take a deeper look into how these groups of road users might differ from one another. As underscored in the introduction, an additional factor to consider when grouping road users is their confidence in their level of understanding as this will impact how they use or interact with the systems.

Clusters of Road Users Based on Knowledge and Confidence

As noted above, Carney and colleagues (2022) identified clusters of drivers based on results from a mental model assessment. Four clusters were defined not only by actual understanding (i.e., mental model strength) of ACC, but also by confidence in that level of understanding. Carney and colleagues labeled these clusters as follows:

- Weak Confident (WC)—low mental model assessment understanding scores and high confidence
- Weak Unconfident (WU)—low mental model assessment understanding scores and low confidence
- Strong Confident (SC)—high mental model assessment understanding scores and high confidence
- Strong Unconfident (SU)—high mental model assessment understanding scores and low confidence

In this section, this approach was adopted and adapted to identify different clusters of drivers in the current sample and contrast them according to their underlying characteristics, experiences, and perceptions. The relationships between mental model assessment scores and mental model confidence scores were explored prior to the cluster analysis. A moderate relationship (r = .44, p < .001) was observed between ACC mental model assessment scores and LKA mental model assessment scores. A strong relationship (r = .70, p < .001) was observed between ACC mental model confidence scores and LKA mental model confidence scores. No relationship was observed, however, between mental model assessment scores and mental model confidence scores for ACC or LKA. This suggests that there is no relationship between a road users' understanding of ACC or LKA and their confidence of their understanding.

A cluster analysis was performed to replicate the outcomes observed by Carney and colleagues (2022). Data included in the cluster analysis were overall mental model assessment score (% correct) and mental model confidence score (%) for both ACC and LKA. The key difference in the current approach is the inclusion of both ACC and LKA, whereas Carney and colleagues (2022) explored only ACC. After scaling the data, a k-means cluster analysis was performed using the k-means function in R to divide participants into four groups. The clusters were assigned the names in the bulleted list above based on their MMA scores and confidence scores. The largest group of respondents were classified as SC whereas the smallest group were the WC, representing 34% and 19.7% of the respondents, respectively.

Based on clustering, mental model assessment scores and mental model confidence are displayed in Table 4 and Figure 10. An index score was also computed by dividing respondents' confidence by understanding for ACC and LKA. The index offers an additional metric to compare groups in terms of the degree of calibration between accuracy scores and confidence. An index equal to one indicates good alignment between knowledge and confidence (e.g., 80% confidence in responses while score 80% in accuracy). Scores greater than one indicate over-confidence while scores less than one indicate under-confidence. As shown in Table 4, confidence was a key characteristic to differentiate respondents within the same understanding group as indices were much higher in the WC and SC groups compared to their WU and SU counterparts. Interestingly, the WC was the only group to score in the over-confident range (>1), with the other groups falling in the under-confident (<1) range—the departure from one being most significant in the SU group. This pattern of results further corroborates the outcomes of the clustering exercise.

Table 4. Number of participants, mean overall mental model assessment, and confidence by clusters.

Cluster	N	ACC			LKA		
		Accuracy[1]	**Confidence[2]**	**Index[3]**	**Accuracy[1]**	**Confidence[2]**	**Index[3]**
WC	497	48.2	73.2	1.52	47.2	69.8	1.48
WU	662	48.1	41.4	0.86	47.7	35.1	0.73
SC	861	70.1	64.5	0.92	85.0	64.6	0.76
SU	539	67.9	29.6	0.43	81.9	22.1	0.26

[1] *% Correct on mental model assessment.*

[2] *% Confidence.*

[3] *(% Confidence/% correct on mental model assessment).*

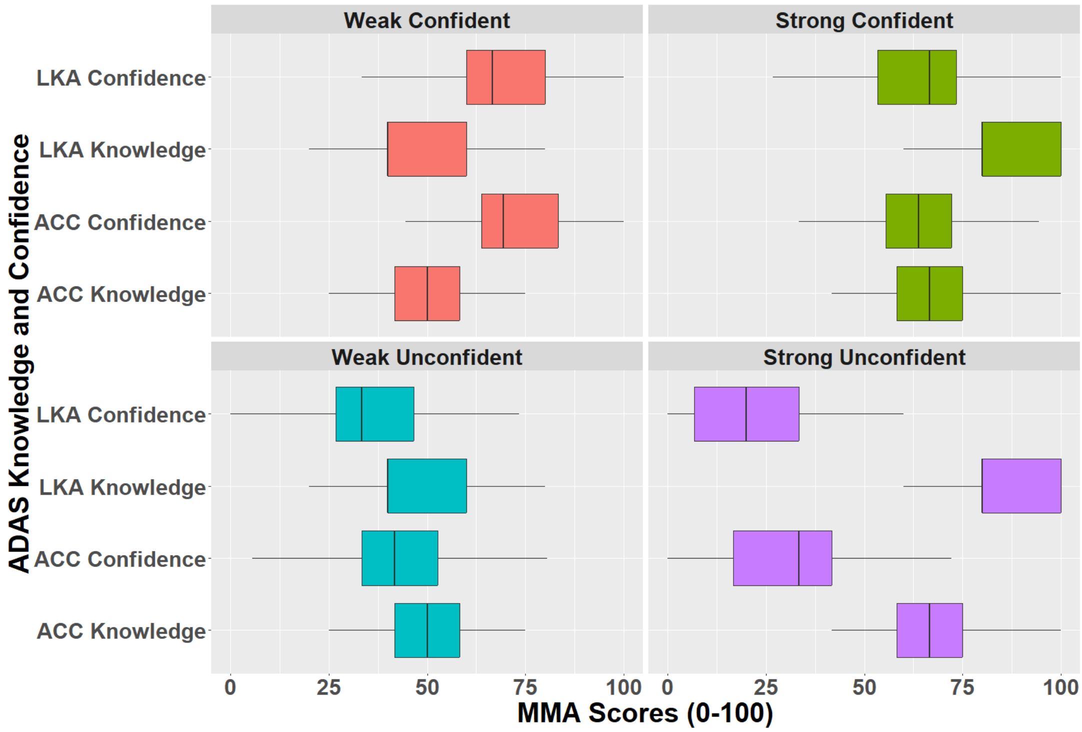

Figure 10. Mental model assessment scores and confidence for both ACC and LKA between the clusters.

Demographics and Driving Experience

The demographics, driving habits, and driving confidence scores for all four clusters are displayed in Table 5. Age was similar between clusters although the WC cluster was slightly older than the other clusters. Males were overrepresented in both confident clusters (WC and SC) and made up 62% of the WC cluster. Drivers in the WC group tended to rate their own driving confidence and safety higher than drivers in the other groups.

Table 5. Road users' demographics and driving characteristics by cluster.

Variables	Clusters			
	WC (n=497)	**WU (n=632)**	**SC (n=861)**	**SU (n=539)**
Mean Age, in years (SD)	50.1 (15.4)	46.1 (15.3)	44.4 (15.7)	44.2 (16.5)
Sex				
Male	310 (62%)	295 (47%)	476 (55%)	218 (40%)
Female	183 (37%)	333 (53%)	378 (44%)	312 (58%)
Education				
Did not complete HS	2 (<1%)	4 (1%)	2 (<1%)	5 (1%)
HS or GED	52 (11%)	77 (12%)	78 (12%)	65 (12%)
Some college	95 (19%)	126 (20%)	175 (20%)	137 (26%)
AA	62 (13%)	72 (12%)	78 (9%)	71 (13%)
BS	186 (38%)	241 (38%)	345 (40%)	176 (33%)
Graduate degree	96 (19%)	106 (17%)	176 (21%)	76 (14%)
Driving Frequency				
Never driven	9 (2%)	14 (2%)	4 (<1%)	13 (2%)
Driving cessation	7 (1%)	24 (4%)	19 (2%)	16 (3%)
<3 days/wk	302 (61%)	322 (51%)	476 (55%)	264 (49%)
3-4 days/wk	107 (22%)	128 (20%)	197 (23%)	112 (21%)
≥5 days/wk	72 (14%)	143 (23%)	164 (19%)	134 (25%)
Driving Confidence (0–10)	8.4 ± 1.7	7.5 ± 2.1	8.0 ± 1.7	7.4 ± 2.2
Driving Safety (0–10)	8.6 ± 1.5	8.1 ± 1.8	8.2 ± 1.6	8.0 ± 1.8

Experience with Advanced Driver Assistance Systems

Although a majority of respondents reported that their primary vehicle did not have ACC or LKA, ownership rates differed between the clusters. Specifically, a large proportion of road users in each of the two confident (WC and SC) clusters owned ACC and LKA compared to the unconfident clusters (SU and WU). Compared to the confident clusters, a greater proportion of road users in the unconfident clusters were not certain if their primary vehicle had either ACC or LKA (10%–12% vs 4%–5%). The WC cluster had the greatest proportion of road users that reported owning ACC (43%) or LKA (30%) systems compared to the other clusters. Figure 11 displays the proportion of ACC or LKA ownership between clusters. Interestingly, as shown in Table 6, the confident clusters reported higher values pertaining to their perceived knowledge of the systems (the WC cluster even more so than the SC cluster) and the importance of understanding ADAS in their vehicle and were more confident in their ability to find ADAS educational material compared to the unconfident clusters. Collectively, these findings suggest that owning ADAS may increase their confidence in drivers' understanding of ADAS, but not necessarily their actual understanding.

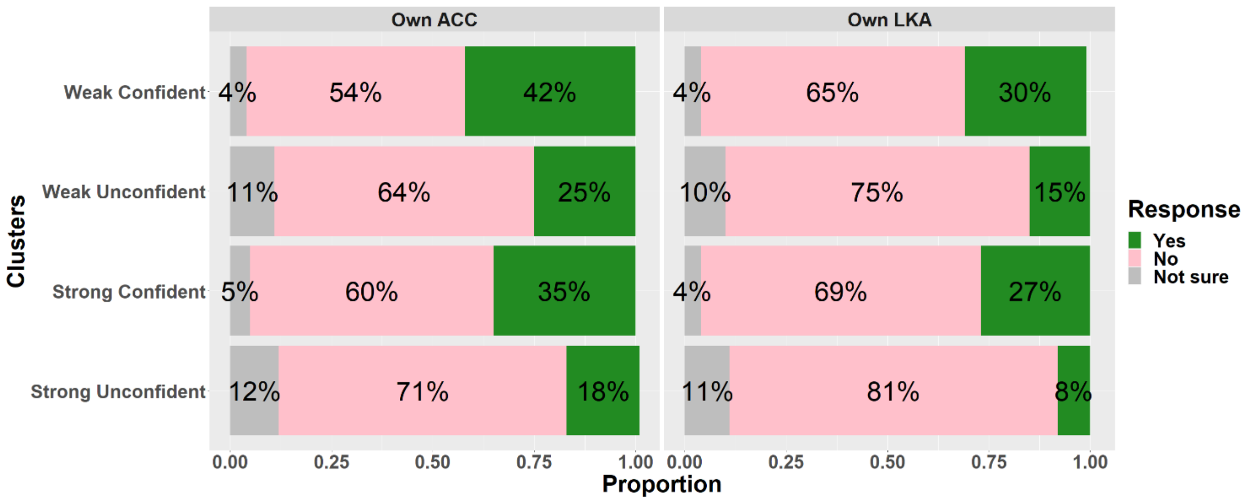

Figure 11. Ownership of ACC and LKA systems between the clusters.

Table 6. Road users experience with ADAS by cluster.

Variables	Clusters WC (n=497)	WU (n=632)	SC (n=861)	SU (n=539)	Total Sample (N=2529)
Self-assessed knowledge of ADAS					
ACC knowledge (0–10)	5.8 ± 2.9	3.8 ± 2.5	5.4 ± 2.8	3.0 ± 2.7	4.6 ± 3.0
LKA knowledge (0–10)	5.2 ± 3.0	2.9 ± 2.4	4.7 ± 2.9	2.0 ± 2.3	3.8 ± 2.9
Importance of Understanding ADAS (0–10)	8.1 ± 2.8	6.9 ± 3.2	7.9 ± 2.9	6.7 ± 3.4	7.4 ± 3.1
Confidence in Finding ADAS Educational Material (0–10)	8.2 ± 2.6	6.9 ± 3.0	8.0 ± 2.5	6.5 ± 3.2	7.5 ± 2.9

Road users in the unconfident clusters (WU & SU) reported being less familiar with ACC and LKA compared to those in the confident clusters. Road users in the WC cluster reported being the most familiar with ACC and LKA followed by the SC cluster. The WC cluster also had the greatest proportion of road users that trust ACC and LKA as seen in Figure 12. In the WC cluster, 79% of road users agreed or strongly agreed that the combination of ACC and LKA reduced the likelihood of being involved in a crash (Figure 12). While ownership, familiarity, and trust in ACC and LKA help to characterize differences in road users between clusters, frequency of system use may provide additional insight to further distinguish these clusters.

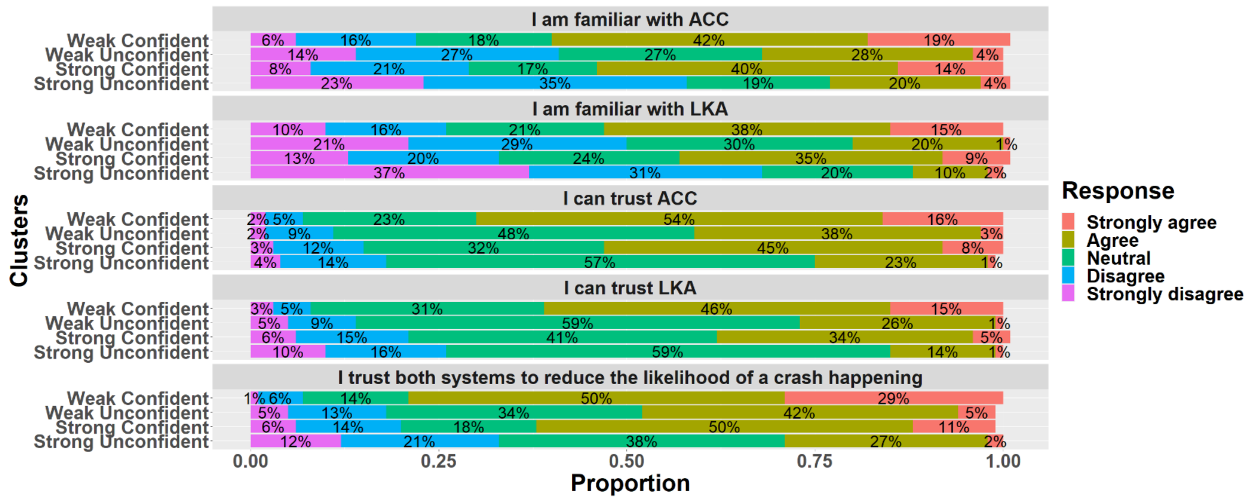

Figure 12. Level of familiarity and trust of ACC and LKA systems between the clusters.

Road users that owned ACC or LKA indicated how frequently they used the systems while on the highway/interstate (Figure 13). Both unconfident clusters (WU & SU) reported using ACC and LKA less frequently compared to the confident clusters (WC & SC). The weak confident cluster reported using ACC and LKA most frequently, which suggests that experience with the system does not necessarily lead to a strong understanding of ACC or LKA.

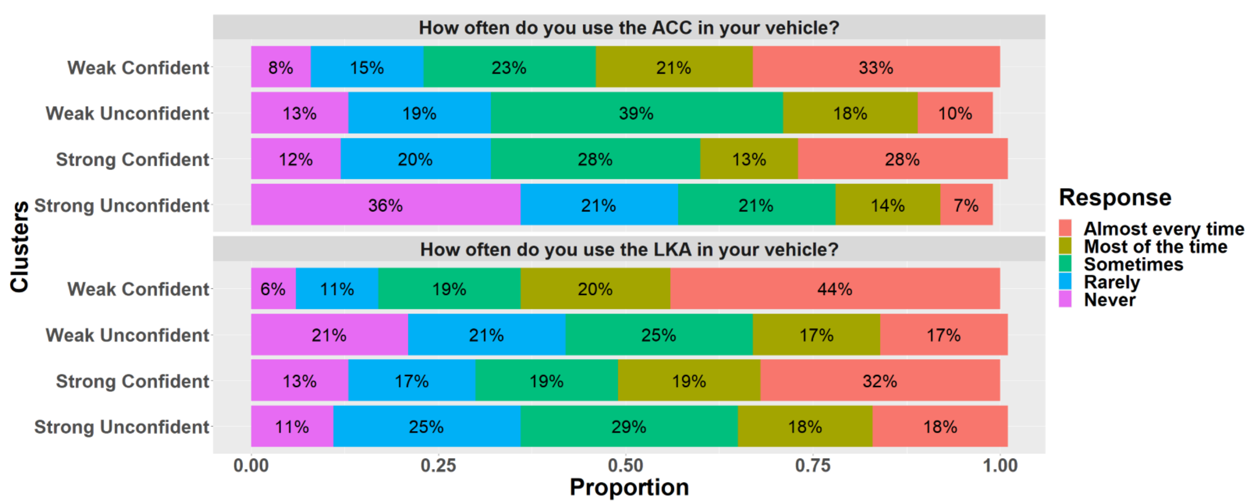

Figure 13. Frequency of ACC and LKA usage between the clusters.

Learning About Advanced Driver Assistance Systems

Overall, there were similarities within the confident clusters and within the unconfident clusters with respect to the methods used to learn about ADAS (Figure 14). However, there were observable differences between the two confident clusters (SC and WC). The confident clusters had a larger proportion of road users that learned about ADAS from the internet, owner's manual, trial and error, and dealership. Interestingly, 25% of SU road users reported never learning about ADAS technology in their vehicle.

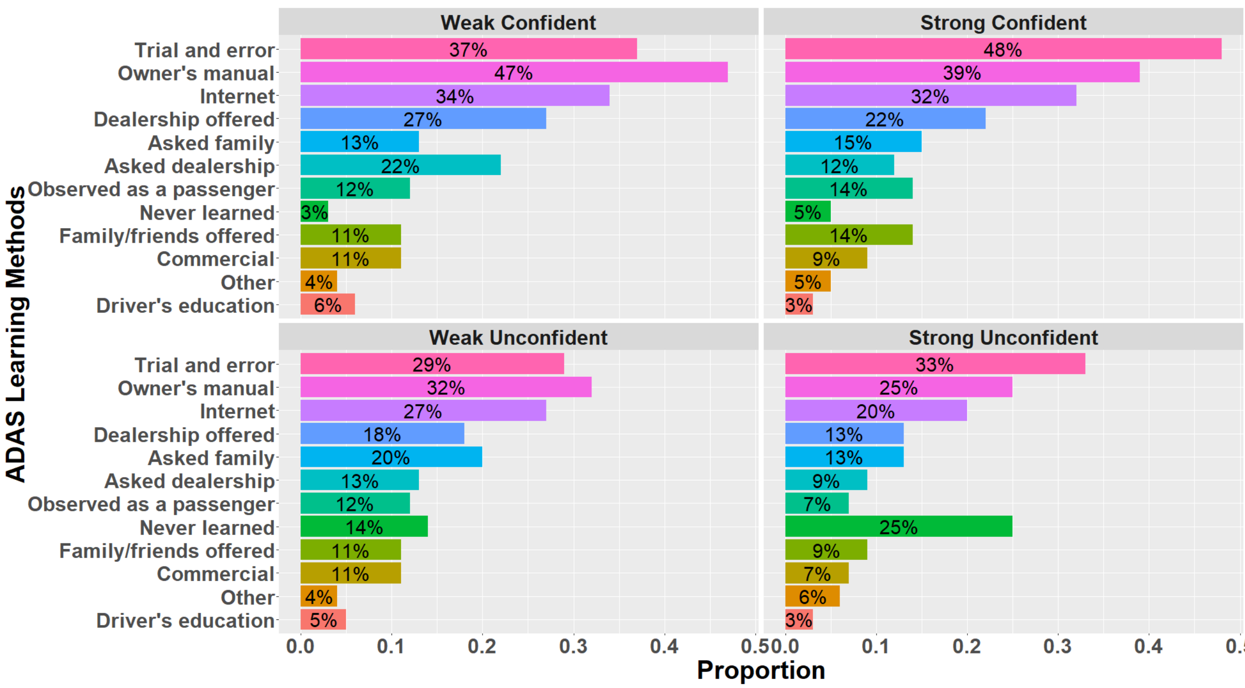

Figure 14. ADAS education methods between clusters.

Although the clusters were quite distinct in how they learned about ADAS, they had very similar preferences for how they would like to learn about ADAS (Figure 15). A majority of road users in all clusters reported preferring to learn about ADAS via trial and error followed by videos and owner's manual.

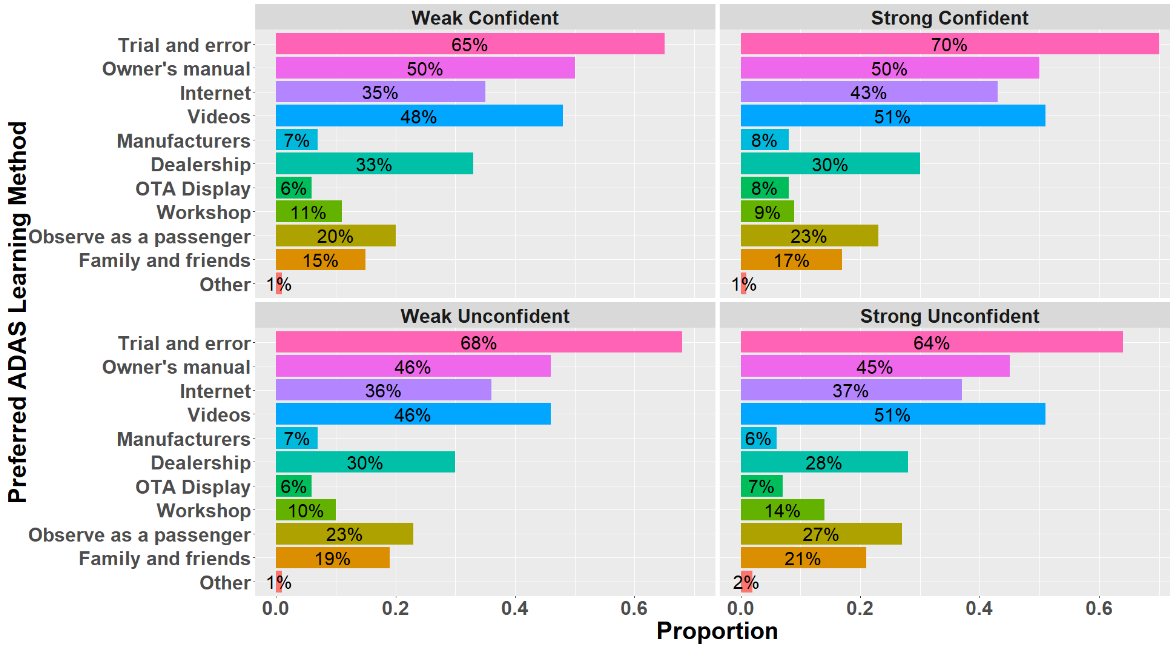

Figure 15. Preference for ADAS education between clusters. OTA = over-the-air.

Perceptions of Technology

The clusters were also examined based on their general perceptions of technology. The confident clusters (WC & SC) reported having more freedom and being more productive due to technology compared to the unconfident clusters (Figure 16). A larger proportion of the confident clusters reported that they kept up with technological developments and that people often came to them for advice about new technologies compared to the unconfident clusters. This suggests that general perceptions of technology might be an indication of their understanding and confidence in their understanding of ADAS.

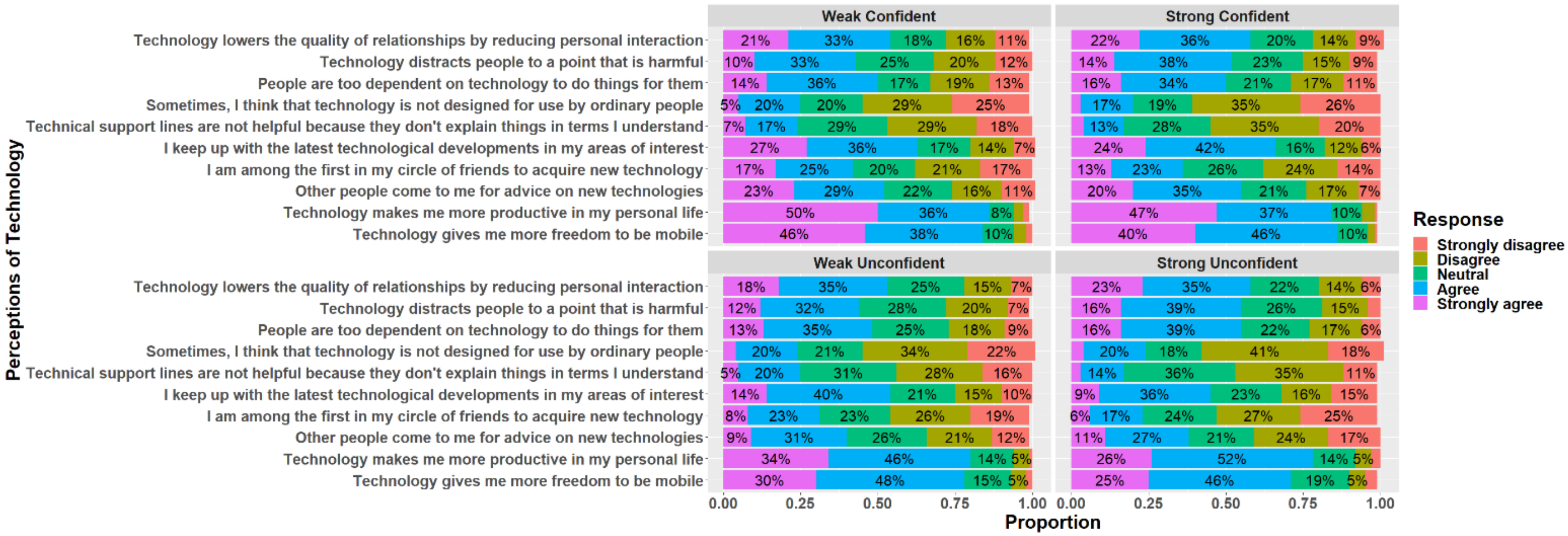

Figure 16. Perceptions of technology between clusters.

Discussion

The first aim of this study was to compare road users with a weak understanding of ADAS (ACC and LKA) to road users with a strong understanding of ADAS. The second aim of this study was to classify road users based on the strength of their mental model of ACC and LKA (i.e., lane keeping and lane centering systems), as well as their confidence in their understanding. Collectively, these two aims help to better understand how drivers differ in their ADAS learning preferences and experiences, driving behavior, familiarity with ADAS, ownership of ADAS, and general perceptions of technology.

Several differences were noted between the weak ADAS understanding group compared to the strong ADAS understanding group. One strength to this approach was the small overlap in ADAS understanding scores between these two groups. Road users with a strong understanding of ADAS were on average 6 years younger than those with a weak understanding of ADAS. Notably, the strong understanding group learned about ADAS via trial and error whereas the weak understanding group learned about ADAS via the owner's manual. A large proportion of the strong understanding group preferred to learn about ADAS via videos and internet compared to the weak understanding group. Interestingly, both groups had similar confidence levels in their understanding of ADAS, reported similar rates of ADAS ownership, and expressed the importance of understanding ADAS. Analysis of the responses to specific items on the mental model assessment suggested that education and training approaches should prioritize information about system limitations: increasing awareness about a system's operational design domain might help reduce some of the gaps between the knowledge groups.

Following Carney et al. (2022) and Lenneman et al. (2020), clusters of drivers were identified with respect to mental model assessment scores and confidence. This cluster analysis revealed four groups, with different levels of mental model quality and confidence: Weak Confident (WC), Weak Unconfident (WU), Strong Confident (SC), and Strong Unconfident (SU). The clusters of road users differed in demographics, driving characteristics, ADAS ownership and experience, perceptions related to ADAS, and preferred learning methods for ADAS.

The clusters with a weak understanding (WC & WU) were older than the clusters with a strong understanding (SC & SU) of ACC and LKA. The clusters with confidence in their understanding (WC & SC) were overrepresented by males, whereas females were overrepresented in the unconfident clusters. Although the age differences were relatively small, age may play an important factor in learning preferences and mental models of ADAS. Age and sex should both be considered when developing education and training for ADAS. Given that females were less confident in their knowledge of ADAS, developing educational material to promote confidence may lead to increased use of

ADAS. Increased confidence or self-efficacy using ADAS increases drivers' intention to use ADAS (Seuwou, 2021).

Both confidence and understanding of ADAS are important prerequisites to the safe use of ADAS. The relationship between confidence and mental model strength is also important as it speaks to the calibration between actual and perceived understanding (Horrey et al., 2015). Miscalibrated mental models could lead to overconfidence (i.e., weak understanding with high confidence) and the misuse or disuse (i.e., strong understanding but low confidence) of ADAS (Mason et al., 2023). Unfortunately, there were no observable relationships between understanding and confidence in their understanding of either ACC or LKA. Interestingly, we found some correspondence between ACC and LKA mental models and a strong relationship between confidence in their mental model of ACC and LKA. Consumer education or training prior to hands-on experience with ADAS may facilitate a closer relationship between drivers' understanding of ADAS and confidence in their understanding of ADAS, potentially leading to safe use of the system. Confidence in ADAS may extend to confidence or self-efficacy in other abilities related to driving and ADAS as seen in this study. The confident clusters (WC & SC) were more confident in their driving abilities and ability to find ADAS educational material, felt that they were safer drivers, believed they had a better understanding of ACC and LKA, and were more trusting of ACC and LKA compared to the unconfident clusters (WU & SU). A greater proportion of road users in the confident clusters owned a vehicle with ACC or LKA and reported more frequent use of these systems compared to the unconfident clusters. However, the strength of their mental model did not seem to be influenced by ownership of either ACC or LKA. That is, owning ADAS may serve to increase a driver's confidence in their knowledge, but not necessarily their actual knowledge.

This is the first study to characterize road users based on their understanding and confidence of their understanding of both ACC and LKA. Developing and deploying an LKA mental model assessment extends findings from semi-structured interviews conducted by Nees and colleagues (2020) where drivers described the sensors, functions, and limitations of LKA, and their responsibilities while using LKA. The intended outcomes of consumer education and training are to enhance the drivers' understanding and confidence in their understanding of ADAS. Specifically, drivers should understand the purpose, functions, limitations of ADAS as well as their responsibilities while using ADAS (Campbell et al., 2018; Manser et al., 2019; McDonald et al., 2017; Panou et al., 2010). While the medium or formatting of consumer education is important, the content should be evaluated first and foremost. A mental model assessment can be used to evaluate the effectiveness of education or training and measure the acquisition of knowledge. Various ACC mental model assessments exist in the literature (Gaspar et al., 2021; Pradhan et al., 2023) and have been used to explore how drivers develop their mental model across time and experience with the system. ACC mental model assessments are also used to better understand the effect of ACC training. A driving simulator, naturalistic driving, or road course can be used to better understand skill acquisition and safe use of ADAS. Future work may consider aligning the intended outcomes of ADAS training and education with the content of the ADAS training and education materials as well as the method of assessment (i.e., driving simulator, mental model assessment).

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Appendix A: Survey

Q1 **Knowledge and Use of Advanced Driver Assistance Systems Survey** Researchers at the University of Iowa are conducting a survey of drivers and other road users regarding their knowledge of different vehicle technologies. The goal is to understand how this knowledge varies across different populations. The survey will ask you questions about your experiences and usage of different vehicle technologies, your knowledge of their functions, types of training you have obtained, as well as general information about you.

To participate, you must be 18 years or older.

If you agree to participate, we would like you to complete the online questionnaire available below. Your response to this survey, or any individual question on the survey, is completely voluntary. You are free to skip any questions that you prefer not to answer. The survey contains the following sections:

- Demographics, Transportation, and Driving – 26 questions
- Experience with Advanced Driver Assistance Systems – 33 questions
- Advanced Driver Assistance Systems Education – 5 questions
- Perceptions of Technology and Driving – 26 questions

The survey should take no more than 30 minutes of your time and you will be paid $5 for your time. You will only be compensated if you complete the survey.

We will not collect your name or any identifying information about you, except for the purpose of payment. At the end of the survey, you will follow a link to provide your payment information. It will not be possible to link you to your responses to the survey with your payment information. If you do not wish to participate in this study, you may simply exit out of your Internet browser.

As part of this study, we are obtaining survey responses. We may further analyze your responses after this study is over. Therefore, if you agree to participate in this study, your responses will be available for use in future research studies indefinitely. Other qualified researchers who obtain proper permission may gain access to your data for use in approved research studies that may or may not be related to the purpose of this study. Your survey data will be stored without your name or any other kind of link that would enable us to identify which responses are yours. It is unlikely that what is learned from these future studies, will have a direct benefit to you. It is possible that your survey responses might be used to develop discoveries that could be patented and licensed. In some instances, these may have potential commercial value and may be developed by the Investigators, University of Iowa, commercial companies, organizations funding this research, or others that may not be working directly with this research team. There are no plans to provide financial compensation to you should this occur.

If you have questions about your rights as a participant in this survey or are dissatisfied at any time with any aspect of the survey, you may contact Justin Mason (xxx@uiowa.edu or xxx-xxx-xxxx), a Research Scientist at the University of Iowa with the study. If you have questions about the rights of research subjects, please contact the Human Subjects Office, 105 Hardin Library for the Health Sciences, 600 Newton Rd, The University of Iowa, Iowa City, IA 52242-1098, (xxx) xxx-xxxx, or e-mail xxx@uiowa.edu.

Q2 Thank you very much for your consideration of this research study.

- ○ Yes, I agree to participate (1)
- ○ No, I do not want to participate (2)

Q3 Please provide your age:

____

Q4 In which month were you born?

- ○ ▼ January (18) ... December (29)

Q5 What is your zip code:

____

Q6 What is your sex?

- ○ Male (1)
- ○ Female (2)
- ○ Prefer not to answer (3)

Q7 How do you identify? Select all that apply:

- ○ American Indian or Alaska Native (1)
- ○ Asian or Asian American (2)
- ○ Black or African American (3)
- ○ Hispanic, Latino, or Spanish origin (4)
- ○ Native Hawaiian or Other Pacific Islander (5)
- ○ White (6)
- ○ Other: (7)
- ○ Prefer not to answer (8)

Q8 What is the highest level of school you have completed?

- ○ Did not complete high school (1)
- ○ High school diploma or GED (2)
- ○ Some education beyond high school but no degree (3)
- ○ Associate degree (4)
- ○ Bachelor's degree (5)
- ○ Advanced degree (e.g., M.S or Ph.D.) (6)

Q9 What is your annual household income?

- Under 29,999 (1)
- $30,000 to $39,999 (2)
- $40,000 to $49,999 (3)
- $50,000 to $69,999 (4)
- $70,000 to $99,999 (5)
- $100,000 to $149,999 (6)
- $150,000 to $199,999 (7)
- > $200,000 (8)
- Prefer not to answer (9)

Q10 What is your marital status?

- Single (1)
- Married (2)
- Divorced (3)
- Separated (4)
- Widowed (5)

Q11 How would you rate your:

	Poor (1)	Fair (2)	Good (3)	Very good (4)	Excellent (5)
Hearing (if applicable, while using hearing aids as usual) (1)	○	○	○	○	○
Eyesight (if applicable, using glasses or lenses as usual) (2)	○	○	○	○	○
Ability to walk (3)	○	○	○	○	○

Q12 Do you use a wheelchair, walker, cane, crutches, or similar assistive devices?

- ◯ No (1)
- ◯ Yes (2)

Q13 Do you have difficulty concentrating, remembering or making decisions?

- ◯ Not at all (1)
- ◯ A little bit (2)
- ◯ Somewhat (3)
- ◯ Quite a bit (4)
- ◯ Very much (5)

Q14 Are you able to run errands alone, such as visiting a doctor's office or shopping?

- ◯ Without any difficulty (1)
- ◯ With a little difficulty (2)
- ◯ With some difficulty (3)
- ◯ With much difficulty (4)
- ◯ Unable to do (5)

Q15 Do you need the assistance of others to complete everyday tasks such as dressing, bathing or getting around the house?

- ◯ No (1)
- ◯ Yes (2)

Q16 What is the make and model of the vehicle you currently own/lease? (If your household has multiple vehicles, pick the one that you drive the most).

- ☐ Year (e.g., 2022) (1) ____
- ☐ Make (e.g., Toyota) (2) ____
- ☐ Model (e.g., Camry (3) ____
- ☐ I do not own/lease a vehicle (4)

Q17 Which of the statements best describes you?

- ○ I have never driven before (1)
- ○ I used to drive but I have stopped driving for good. (2)
- ○ I typically drive fewer than 3 days per week (3)
- ○ I typically drive 3 to 4 days per week (4)
- ○ I typically drive 5 or more days per week (5)

Q18 Which modes of transportation do you use within a typical month? Please select all that apply.

- ☐ Drive myself (1)
- ☐ Ride with others (2)
- ☐ Bicycle (3)
- ☐ Motorcycle or moped (4)
- ☐ Public transportation (e.g., bus, subway) (5)
- ☐ Paratransit (6)
- ☐ Ride-hailing services (e.g., Uber, Lyft, taxi, etc.) (7)
- ☐ Walk (8)

Q19 Which is your primary mode of transportation?

- ○ Drive myself (1)
- ○ Ride with others (2)
- ○ Bicycle (3)
- ○ Motorcycle or moped (4)
- ○ Public transportation (e.g., bus, subway) (5)
- ○ Paratransit (6)
- ○ Ride-hailing services (e.g., Uber, Lyft, taxi, etc.) (7)
- ○ Walk (8)

Q20 How confident do you feel doing the following activities:
Please provide a response from 0-10, where 0 is not confident and 10 is completely confident.

	Not confident	Completely confident	Not Applicable
	0 1 2 3 4 5 6 7 8 9 10		
Driving in your local area (1)			
Driving in unfamiliar areas (2)			
Driving in heavy traffic (3)			
Driving on the highway (4)			
Attempting to merge with traffic (5)			

Q21 Please provide a response from 0 (Much less than average) to 10 (Much more than average).

	Much less than average	Much more than average	Not Applicable
	0 1 2 3 4 5 6 7 8 9 10		
How safe are you while driving? (1)			
How skillful are you at driving? (2)			

Q22 Experience with advanced driver assistance systems Some vehicles are equipped with advanced driver assistance systems that can control some of the driving tasks for you. The questions throughout this section will focus on your experience with and understanding of two of these systems: Adaptive Cruise Control (ACC) and Lane Keeping Assistance (LKA). In some vehicles, ACC and LKA are part of one combined system, whereas in other vehicles, ACC and LKA are separate systems. Here we will describe each system separately. If you have experience using a combined version of ACC and LKA, when answering a question about ACC or LKA, please think about only that aspect of the system.

Adaptive Cruise Control (ACC). This system is designed to control the speed of the vehicle, like normal cruise control, but also automatically slows down and speeds up based on the behavior of the vehicle ahead. Different automotive manufacturers have different names for this technology and in some vehicles. Throughout the survey, we will use the term ACC to refer to any driver assistance system that fits the description above.

<u>Lane Keeping Assistance (LKA).</u> This system is designed to automatically steer the vehicle to stay within the current lane. Some systems steer the vehicle once it begins to approach the lane boundary while others steer continuously to keep the vehicle in the center of the lane. Different automotive manufacturers have different names for this technology. Throughout the survey, we will use the term LKA to refer to any driver assistance system that fits the description above.

Q23 The following questions will ask you about Adaptive Cruise Control (ACC).

Q24 Does your current vehicle have ACC?

- ◯ Yes (1)
- ◯ No (2)
- ◯ Not sure (3)

Q25 When driving on a highway or interstate, how often do you use the ACC in your vehicle?

- ◯ Almost every time (1)
- ◯ Most of the time (2)
- ◯ Sometimes (3)
- ◯ Rarely (4)
- ◯ Never (5)

Q26 Please provide a response from 0 (Not at all) to 10 (A lot).

	Not at all									A lot
	0	1	2	3	4	5	6	7	8	9	10
How much do you know about ACC (1)											

Q27 Please rate your overall agreement with the following statements regarding ACC.

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I can trust the system (1)	○	○	○	○	○
I am familiar with the system (2)	○	○	○	○	○

Q28 For the following statements, determine if the item is True or False. Please indicate how confident you are in your response.

	The statement about ACC is...		Confidence in Response			
	True (1)	False (0)	No Confidence (0)	Slight Confidence (1)	Moderate Confidence (2)	High Confidence (3)
Maintains the speed that you have set when there are no vehicles detected in the lane ahead (1)	○	○	○	○	○	○
Will accelerate if a slower vehicle ahead moves out of the detection zone (2)	○	○	○	○	○	○
Will provide steering input to keep the vehicle in its lane (3)	○	○	○	○	○	○
Will correctly detect motorcycles and other smaller vehicles not driving in the center of the lane (4)	○	○	○	○	○	○
May not correctly detect stopped vehicles in your lane (5)	○	○	○	○	○	○
Reacts to stationary objects on the road (construction cone, tire, ball) (6)	○	○	○	○	○	○
Works well on curvy roads and hills (7)	○	○	○	○	○	○
Adjusts the speed when there are slower moving vehicles detected ahead (8)	○	○	○	○	○	○
Will react immediately to vehicles merging onto the road in front of you (9)	○	○	○	○	○	○
Is meant to be used on rural roads (10)	○	○	○	○	○	○
May not correctly detect vehicles ahead traveling at much slower speeds (11)	○	○	○	○	○	○
Can handle operating in all weather conditions (12)	○	○	○	○	○	○

Q29 The following questions will ask you about Lane Keeping Assistance (LKA).

Q30 Does your current vehicle have LKA?

- ○ Yes (1)
- ○ No (2)
- ○ Not sure (3)

Q31 How does your vehicle's LKA system work?

- ○ Upon lane departure, it pulls the vehicle back into the lane (1)
- ○ It keeps the vehicle centered in the lane (2)
- ○ Not sure (3)

Q32 What motivated you to have LKA in your vehicle?

- ○ A test drive in the dealership (1)
- ○ Recommendation from salesperson (2)
- ○ Recommendation from friend or family (3)
- ○ Read about it (4)
- ○ Advertisements (5)
- ○ Didn't know my vehicle had LKA until after buying it (6)
- ○ Other (please describe): (7) ____

Q33 When driving on a highway or interstate, how often do you use the LKA in your vehicle?

- Almost every time (1)
- Most of the time (2)
- Sometimes (3)
- Rarely (4)
- Never (5)

Q34 Please provide a response from 0 (Not at all) to 10 (A lot).

	Not at all								A lot		
	0	1	2	3	4	5	6	7	8	9	10
How much do you know about LKA ()											

Q35 Please rate your overall agreement with the following statements regarding LKA.

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I can trust the system (1)	○	○	○	○	○
I am familiar with the system (2)	○	○	○	○	○

Q36 For the following statements, determine if the item is True or False. Please indicate how confident you are in your response.

	The statement about LKA is...		Confidence in Response			
	True (1)	False (0)	No Confidence (1)	Slight Confidence (2)	Moderate Confidence (3)	High Confidence (4)
LKA will provide steering input to keep the vehicle in its lane (1)	○	○	○	○	○	○
LKA can operate in all weather conditions (2)	○	○	○	○	○	○
LKA will drive where lane lines are faded (3)	○	○	○	○	○	○
LKA works on curvy roads (4)	○	○	○	○	○	○
LKA can drive in a work zone where lanes have shifted from their usual location (5)	○	○	○	○	○	○
LKA can work with direct sun glare ahead (6)	○	○	○	○	○	○
LKA will change lanes to pass a slower moving vehicle ahead (7)	○	○	○	○	○	○

Q37 Please rate your overall agreement with the following statements regarding ACC and LKA combined.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I trust both systems to reduce the likelihood of a crash happening (1)	○	○	○	○	○

Q38 In the past 2 years, how many crashes have you been involved in while you were driving, including those that were not your fault?

- ○ None (1)
- ○ 1 crash (2)
- ○ 2 crashes (3)
- ○ 3 crashes (4)
- ○ 4 crashes (5)
- ○ More than 4 crashes (6)

Q39
The following questions will ask you about advanced driver assistance systems.
Advanced driver assistance systems, for example ACC or LKA, can control some of the driving tasks for you.

Q40 How did you learn about advanced driver assistance systems in your vehicle? Select all that apply.

- ▢ Read the owner's manual (1)
- ▢ Asked sales staff at the dealership for information (2)
- ▢ Sales staff at the dealership offered information (e.g., you did not specifically ask) (3)
- ▢ Asked a friend or family member for information (4)
- ▢ Friends or family were talking about advanced driver assistance systems (e.g., you did not specifically ask) (5)
- ▢ Looked for information on the internet (6)
- ▢ Saw a video or commercial by chance (7)
- ▢ Observed the advanced driver assistance systems as a passenger (8)
- ▢ Figured it out myself (9)
- ▢ Driver education class (10)
- ▢ Never learned (11)
- ▢ My vehicle doesn't have a driver assistance system (12)
- ▢ Other (please describe): (13) ____

Q41 How much did information from each source contribute to your understanding of the advanced driver assistance systems in your vehicle?

	Not at all 0	1	2	3	4	5	6	7	8	9	A lot 10
Read the owner's manual (1)											
Asked sales staff at the dealership for information (2)											
Sales staff at the dealership offered information (e.g., you did not specifically ask) (3)											
Asked a friend or family member for information (4)											
Friends or family were talking about advanced driver assistance systems (e.g., you did not specifically ask) (5)											
Looked for information on the internet (6)											
Saw a video or commercial by chance (7)											
Observed the advanced driver assistance systems as a passenger (8)											
Figured it out myself (9)											
Driver education class (10)											
Never learned (11)											
My vehicle doesn't have a driver assistance system (12)											
Other (please describe): (13)											

Q42 How would you prefer to learn about advanced driver assistance systems?
Select all that apply.

- ☐ Read the vehicle manual (1)
- ☐ Hands on experience (2)
- ☐ Sales staff at the dealership (3)
- ☐ Ask a friend or family member for information (4)
- ☐ Find information on the internet (5)
- ☐ Watch online videos (6)
- ☐ Observe the advanced driver assistance systems as a passenger (7)
- ☐ Complete a training workshop over the weekend (8)
- ☐ Over-the-air updates that appear on my information display (9)
- ☐ Emails/text messages from the manufacturer (10)
- ☐ Other (please describe): (11) ____

Q43 Please provide a response from 0 (Not at all) to 10 (A lot).

	Not at all 0	1	2	3	4	5	6	7	8	9	A lot 10
It is important for me to understand how the advanced driver assistance systems work in my vehicle? (1)											
I am confident in my ability to find information I need about the advanced driver assistance systems in my vehicle (2)											

Q44 Please rate your overall agreement with the following statements regarding technology (internet, computer, mobile devices, etc.):

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Technology gives me more freedom to be mobile. (1)	○	○	○	○	○
Technology makes me more productive in my personal life. (2)	○	○	○	○	○
Other people come to me for advice on new technologies. (3)	○	○	○	○	○
In general, I am among the first in my circle of friends to acquire new technology. (4)	○	○	○	○	○
I keep up with the latest technological developments in my areas of interest. (5)	○	○	○	○	○
Technical support lines are not helpful because they don't explain things in terms I understand. (6)	○	○	○	○	○
Sometimes, I think that technology is not designed for use by ordinary people. (7)	○	○	○	○	○
People are too dependent on technology to do things for them. (8)	○	○	○	○	○
Technology distracts people to a point that is harmful. (9)	○	○	○	○	○
Technology lowers the quality of relationships by reducing personal interaction. (10)	○	○	○	○	○

Q45 How often do you engage in the following activities?

	Never (1)	Rarely (2)	Some times (3)	Very Often (4)	Always (5)
Drive fast just for the thrill of it (1)	○	○	○	○	○
Deliberately disregard the speed limits late at night or very early in the morning (2)	○	○	○	○	○
Speed up if someone is trying to pass (3)	○	○	○	○	○
Take some risks when driving because it makes driving more fun (4)	○	○	○	○	○
Turn right on to a main road into the path of an oncoming vehicle that you had not seen, or whose speed you had misjudged (5)	○	○	○	○	○
Fail to notice, because lost in thought or distracted, someone waiting at a cross walk (6)	○	○	○	○	○
Misjudge the speed of a moving vehicle when overtaking (7)	○	○	○	○	○
Honk your horn or flash your lights in anger at other drivers (8)	○	○	○	○	○
Forget where you left your car in a multi-level parking lot (9)	○	○	○	○	○
Get into the wrong lane at a roundabout or when approaching a road junction (10)	○	○	○	○	○
Ride in a vehicle driven by someone who has had too much alcohol (11)	○	○	○	○	○
Fail to read the signs correctly, and exit from a roundabout on the wrong road (12)	○	○	○	○	○
Follow very close behind slower drivers (13)	○	○	○	○	○
Take off on a trip with no pre-planned route or schedule (14)	○	○	○	○	○
Drive while talking on the phone (15)	○	○	○	○	○
Drive while texting (16)	○	○	○	○	○

Q46

Please click submit responses in the yellow box below. This will redirect you to a separate payment form where you can provide the requested information to receive compensation ($5 electronic gift card).

The gift card will be sent from the Iowa Social Science Research Center to your email address within 4 weeks.

The University of Iowa and AAA Foundation for Traffic Safety thank you for completing our survey.