RESEARCH BRIEF

Users' Understanding of Automated Vehicles and Perception to Improve Traffic Safety — Results from a National Survey

December 2019

As development and testing of automated vehicle (AV) technologies grow, many advanced driver assistance systems are rapidly being deployed (Zmud & Reed, 2019). This movement is largely due to their potential benefits in reducing crashes and crash severity (e.g., Fagnant and Kockelman, 2015; Benson et al., 2018). However, empirical evidence for these safety benefits remains inconclusive (Sivak and Schoette, 2015; Strayer et al., 2017; Noy et al., 2018), and the general public remains uneasy about these technologies. Although there is a relatively large volume of literature studying people's perceptions of AVs, there has been limited attention paid to the source of their distrust and discomfort. Hence, the AAA Foundation for Traffic Safety (AAAFTS) conducted a nationwide survey assessing:

1. People's understanding of AVs;
2. Their expectations and concerns about AVs, and;
3. Rationales behind their distrust and discomfort toward AVs.

Survey results indicated that people generally perceived higher levels of vehicle automation as potentially more effective than lower levels in preventing crashes related to specific driving behaviors (e.g., distracted driving) and situations (e.g., traffic congestion). However, concerns about AV technologies increased as the level of technology increased, with Society of Automotive Engineers (SAE) Level 5 automation (see Table 1) receiving the greatest degree of distrust. Focus group discussions and post-survey interviews revealed that respondents' concerns and distrust stem from unfamiliarity with the technology and perceived unreliability with current AV technologies. This study stresses the need for technology to be safer and more reliable, as well as the role of public awareness and education to increase people's trust.

METHODOLOGY

Data were collected in three phases: 1) pre-survey focus groups, 2) survey implementation and 3) post-survey follow-up interviews.

Phase 1: Pre-survey focus group

Focus group discussions gathered information regarding perceptions about AV technologies, in-vehicle information systems and traffic safety. Participants also tested potential survey questions about vehicle technologies. The groups included 12 participants in Austin, Texas and 11 in Bethesda, Maryland that were equally balanced in age (18+), sex and ownership of vehicles with advanced driver assistance systems (e.g., adaptive cruise control, lane-keeping assist, blind spot warning, etc.).

A two-hour guided discussion addressed topics including: 1) perceptions of driving safety, 2) awareness, knowledge, and perceptions of AV technologies and in-vehicle infotainment systems, and 3) reactions to descriptive videos about AV technologies. Participants also completed a pilot testing survey, which included questions about their experience with, concerns about, and perceptions of AV technologies. Results from these discussions aided in the development of the final questionnaire. To address participants' limited understanding of AV technologies (as identified in the focus group testing), a video describing AV levels was subsequently developed based on the SAE International definitions (see Table 1). Survey respondents were instructed to watch the video prior to answering the AV-related questions.

Phase 2: Survey implementation

The survey was administered as a part of the 2018 *Traffic Safety Culture Index (TSCI)*, a nationally representative

survey that identifies and assesses Americans' attitudes and behaviors concerning traffic safety (AAA Foundation for Traffic Safety, 2019). TSCI has been conducted annually since 2008. As part of the 2018 survey revisions, a newly developed set of questions regarding AVs (developed in Phase 1) was included.

A total of 3,349 respondents over the age of 16 (2,432 adults and 917 teens) were recruited using KnowledgePanel®, a probability-based online panel designed to be representative of the United States' population (GfK, 2016). The survey was administered in both English and Spanish between Aug. 21 and Sept. 11, 2018. Details about questionnaire development, data collection methodology as well as the overall findings of non-AVs related topics are available in the 2018 TSCI annual report (AAA Foundation for Traffic Safety, 2019).

Phase 3: Post-survey follow-up interview

Based on the preliminary results from the completed survey in Phase 2, follow-up phone interviews were conducted on a subset of respondents (n = 93). Twelve analytical interview groups were formed to represent the overall sample in terms of geographical distribution, age, and sex. Interview questions probed for additional information about particular responses to previous questions, such as why an individual did not trust Level 5 automation in avoiding crashes. Therefore, each interview was unique and customized based on an individual's online survey responses.

Analysis

Descriptive analyses were conducted using a sample of licensed drivers ages 16 or older who reported driving in past 30 days (adults = 2,157 and teens = 425). This brief summarizes the survey results as well as findings from the follow-up interviews on the following topics:

- Understanding of AV levels.
- Trust in AV technologies for crash prevention.
- Perception on effectiveness of AV technologies for crash prevention.
- Potential concerns with AV technologies.

RESULTS

Survey

Understanding of AV levels. Respondents rated their level of understanding of AV technology after viewing the embedded three-minute video describing each level of AV. As shown in Figure 1, 68% of respondents reported that they had a very good or excellent understanding of the levels of AV technology. About 5% of respondents reported little or no knowledge of the levels of AVs.

Trust in AV technologies for crash prevention. Respondents were asked how much they would trust each level of AV technology (Levels 2–5) to reduce a crash occurrence. Figure 2 shows that respondents trusted lower level AVs (2 and 3) more than higher levels (4 and 5). Nearly 30% strongly *distrusted* fully automated vehicles (Level 5), while only 6% of respondents strongly *distrusted* Level 2 to reduce the likelihood of a crash. However, Figure 3 shows that as people's understanding of AV technology increased so did their trust in fully automated vehicles.

When looking at age and sex, results showed that a slightly higher proportion of men trusted AV technology, compared with women, at all AV levels except for Level 5 (Figure 4). Also, in general, a slightly higher proportion of older respondents (75 years and older) trusted Level 2 AV compared with those in other age groups (Table 2). On the other hand, higher proportions of younger respondents (16–59 years) trusted Levels 3 and 4 AV compared with those in older age groups.

Perception on effectiveness of AV technologies for crash prevention. As shown in Table 3, overall respondents perceived higher level AVs as more effective than lower level AVs in preventing crashes due to dangerous driving behaviors and challenging driving situations. For example, 60% of respondents perceived Level 5 as effective in preventing crashes due to drowsy driving, while 21% felt the same way about Level 2. Meanwhile, crashes caused by traffic congestion and bad weather conditions were reported as the least likely to be prevented by fully automated vehicles (Level 5).

Potential concerns with AV technologies. Respondents were asked to rate their degree of concern for each AV level across eight different circumstances listed in Table 4. As shown, concerns increased as the level of vehicle automation increased. Fear that the technology might malfunction was the biggest concern across all AV levels. For Levels 3 and 4, the second biggest concern was the possibility that drivers might become over-reliant on the technology. Respondents were also asked about two negative implications that were related only to Levels

2–4: confusion about how and when to use technologies, and distraction or annoyance due to these technologies. Similar to other concerns, confusion and distraction concerns escalated with increasing level of technology.

Post-survey follow-up interviews

Understanding of AV levels. AVs are a popular topic and Level 2 vehicles are already in the market. Therefore, it is not surprising that some respondents were already knowledgeable and had experience with certain vehicle technologies from their cars. Interestingly, they were extremely positive about the future of vehicle automation and seemed very comfortable with automated vehicles.

A respondent having a car at a Level 2 stated that "It's able to drive itself quite well. I wouldn't mind moving to the next level or two." However, some respondents admitted that they did not even realize there were different levels of vehicle automation. About 41% of respondents stated that the video embedded in the survey helped increase their general knowledge on AVs.

Trust in AV technologies for crash prevention. Post-survey interviews revealed that distrust for AVs mainly arose from unfamiliarity with the technology and their perceived unreliability. Many respondents agreed that AVs would eventually improve traffic safety. However, given how new these technologies are, many people lack adequate understanding about their capabilities and benefits. Further, respondents felt the current technology has not yet been rigorously tested to be reliable and trustworthy. The following summarizes some of the specific thoughts generated by respondents for why they distrust in AV technology.

- Few people have been in a fully automated vehicle. Thus, information people have about these technologies have come from media (Levin and Wong, 2018). Negative news stories about automated vehicles crashing and taking lives engender a great deal of fear about AV technologies.
- As there are potentially hundreds of reasons and circumstances for a crash to occur, many people reported these vehicles as not being ready or fully capable yet of being trusted to account for all causes of crashes.
- In some crashes, it is widely considered that there are certain split-second and/or ethical decisions that only a human would be able to make.

Reflecting people's significant degree of distrust in AV technology, many respondents claimed that a driver needed to be in control of the vehicle. Consequently, the majority of respondents reported Levels 2 or 3 to be the most comfortable to drive/own because of the option to take over vehicle control when desired.

Perception on effectiveness of AV technologies for crash prevention. Post-survey interview results found that respondents generally held positive beliefs about AV technologies and had optimistic expectations of their overall safety benefits.

One respondent claimed, "I have concerns, but these are far outweighed by the safety and convenience of the technology." Many respondents admitted that higher levels of AVs would be more effective than lower levels in preventing crashes due to dangerous driving behaviors, such as distracted driving caused by a mobile phone. In addition to safety benefits, several older respondents looked at the future of vehicle automation as a way for them to maintain greater mobility without having to rely on driving.

Potential concerns with AV technologies. Many respondents noted concerns especially related to Levels 2, 3 and 4 as summarized below.

- Confusion on how and when to use partial automation technologies. In addition, many older drivers indicated confusion about how to operate vehicles at different automation levels.
- Uncertainty of the time needed to take over control of the vehicle.
- Distraction from over-corrections or errors related to partial automation. For example, an automatic braking system engaging when nothing is there.
- Driver inattentiveness and over-reliance on the automated technology while it is operating.

People were also concerned about a glitch, malfunction or a system breakdown comparing to their experience with computers and cell phones. Hackers overriding a vehicle were another concern.

DISCUSSION

Although people generally perceived higher levels of vehicle automation as more effective in preventing crashes related to specific driving behaviors and situations, their

degree of concern with AV technology increased as levels of automation increased. They expressed the greatest degree of distrust for Level 5. Post-survey interviews helped to understand these contradicting findings. Respondents indicated distrust and concern due to the demonstration of their unreliable performance and insufficient testing on today's roads. Respondents noted that there were too many unknown road hazards that AV technologies would not be fully capable of detecting. Additionally, they expressed concern about system glitches or malfunctions, which could potentially cost someone's life.

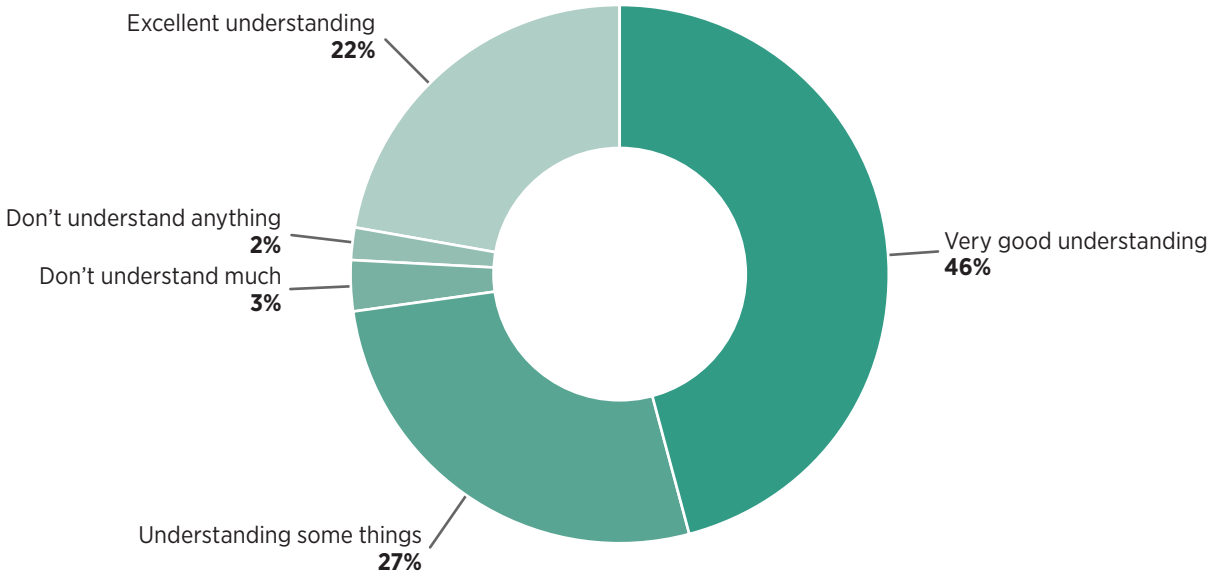
However, the present study results also showed that many respondents recognize the potential safety benefits when Level 5 automation is fully realized. Trust in higher levels of AV technology in reducing the likelihood of a crash increased as respondents' level of understanding and experience with AV technology increased. This finding aligns with results from a previous study that AAAFTS conducted with the University of Iowa (McDonald *et al*., 2018). According to results of that study, two in three owners of vehicles equipped with advanced driver assistance system (e.g., adaptive cruise control, lane departure warning, etc.) reported that they trusted the technology.

This study stresses the need for technology to be safer and more reliable. Errors made by current technologies reduce drivers' confidence in AVs. To mitigate these concerns and increase people's trust we need to collaborate with stakeholders from the research community, government and industry to identify and make necessary improvements. This study also highlights the important role of public awareness and messaging about AVs, which is often negative. Education regarding how these technologies operate (both capabilities and limitations) may help dissuade these concerns.

As part of a continuous effort to advance AV technologies and help the public better understand and utilize these technologies, AAAFTS has organized annual technical forums during the past few years. These forums allow stakeholders from various sectors to discuss and identify challenges and research needs related to vehicle technologies for all road users (AAA Foundation for Traffic Safety, 2017; 2018). AAAFTS will continue contributing to the new transportation era with activities, aiming for adequate and safe use of AV technologies.

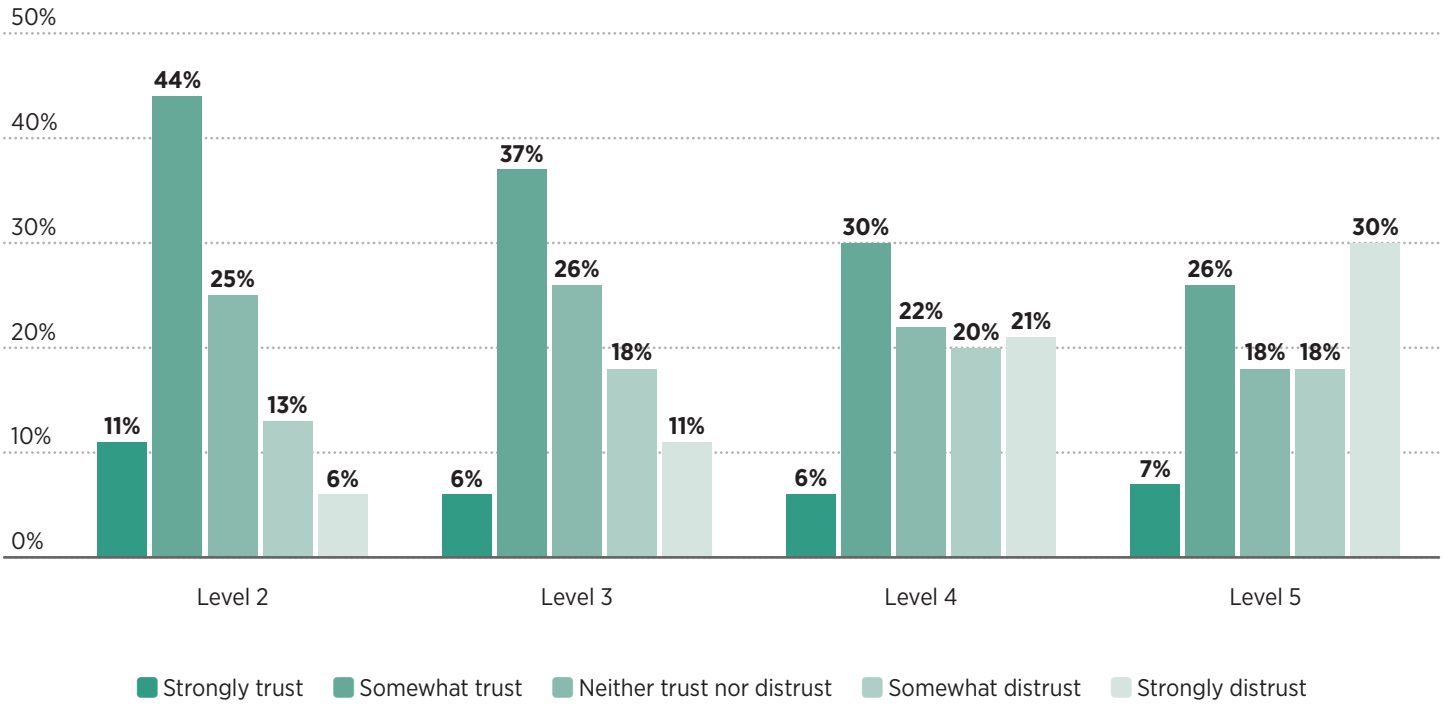
Table 1. Levels of Vehicle Automation Defined by SAE International

Level	0 None	1 Assistance	2 Partial	3 Conditional	4 High	5 Full
What Vehicle Does	**Nothing** *(zero automated technology)*	**Assists** accelerate, brake, or steer *(e.g., intelligent cruise control)*	**Assists** accelerate, brake, and steer *(e.g., intelligent cruise control plus lane keep assist)*	**Everything** for short periods of time *(e.g., traffic jam chauffer)*	**Everything** within a restricted operating environment *(e.g., campus, first/last mile)*	**Everything** *(self-driving anywhere, anytime)*
What Driver Does	**Everything**	**Everything** with some assistance	**Everything** with more assistance	**Be Ready** to resume control when prompted by system	**Nothing** within a restricted operating environment	**Nothing**



* Note: Respondents were asked "How would you rate your understanding of the levels of automated vehicle technology?"

Figure 1. Understanding of AV Levels



* Note: Respondents were asked "How much would you trust level X technology to reduce the likelihood of a crash happening?" for each level of AV technology.

Figure 2. Trust in AV Levels to Reduce the Likelihood of a Crash

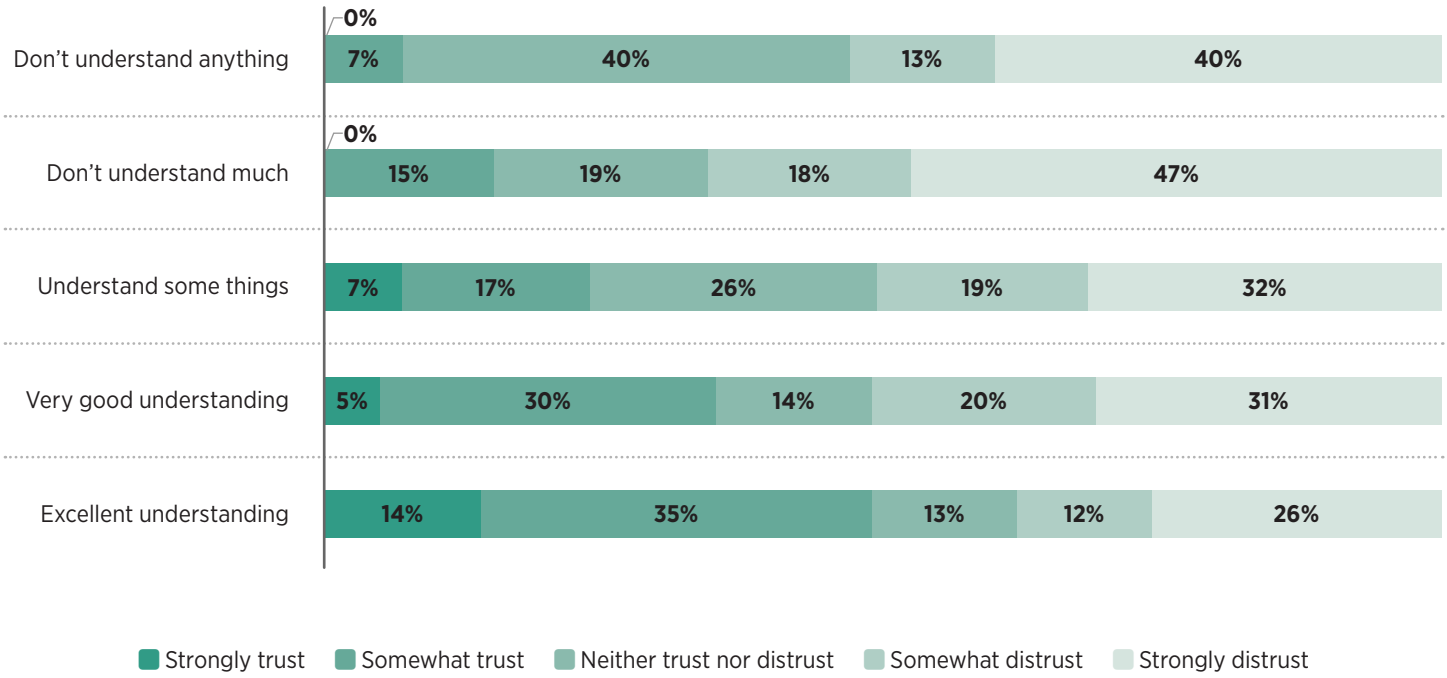


Figure 3. Trust in Level 5 AV in Relation to Understanding of AV Technologies

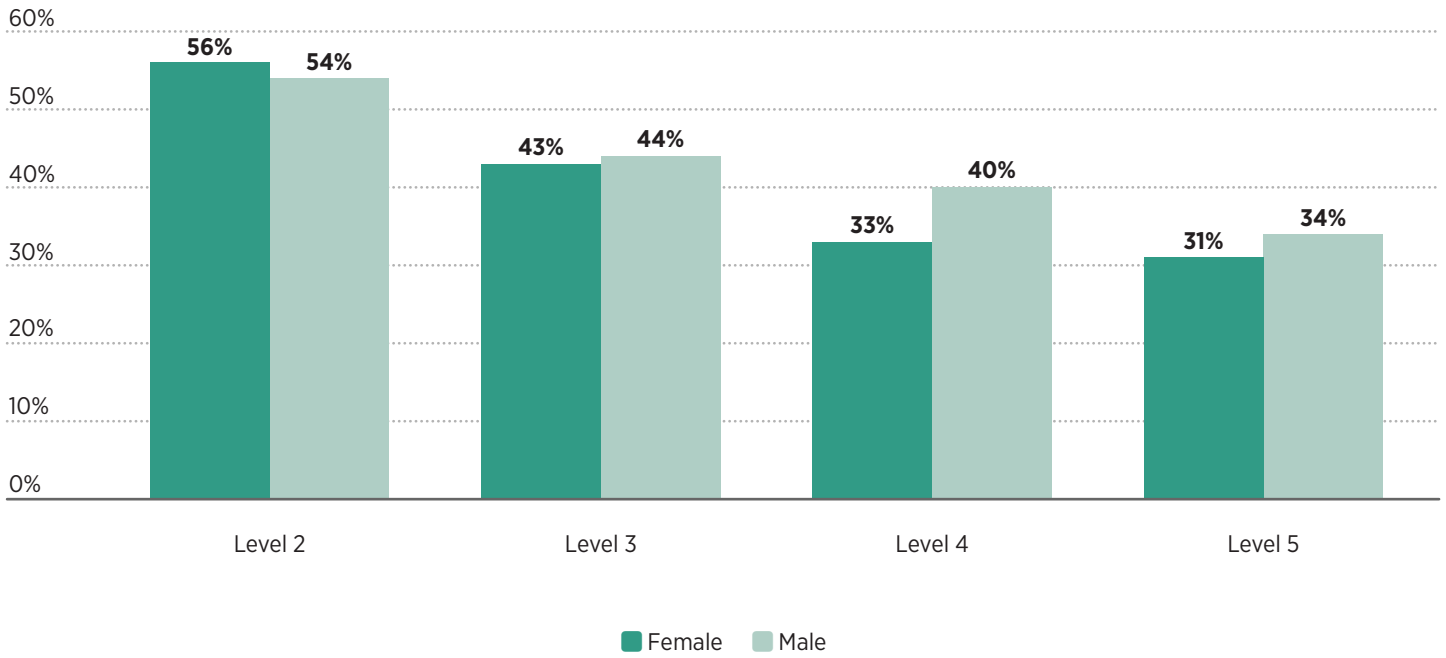


Figure 4. Trust (Strongly or Somewhat) in AV Technologies to Reduce the Likelihood of a Crash in Relation to Responders' Sex

Table 2. Trust (Strongly or Somewhat) in AV technologies to Reduce the Likelihood of a Crash in Relation to Responders' Age

Age Group	Level 2	Level 3	Level 4	Level 5
16-18	60%	50%	43%	39%
19-24	61%	50%	51%	35%
25-39	53%	44%	42%	43%
40-59	53%	43%	34%	32%
60-74	55%	42%	29%	23%
>=75	63%	41%	27%	26%

Table 3. Perception of Effectiveness (Extremely or Very) of AV Technologies for Crash Prevention due to Dangerous Driving Behaviors and Challenging Situations

Driving Behaviors/ Challenging Situations	Level 2	Level 3	Level 4	Level 5
Mobile Phone	22%	35%	50%	61%
Speeding	26%	39%	47%	56%
Running Red Lights	26%	40%	47%	56%
Driving Aggressively	26%	36%	44%	56%
Drowsy Driving	21%	30%	48%	60%
Impaired (Alcohol) Driving	19%	26%	47%	59%
Impaired (Drugs) Driving	18%	25%	46%	59%
Congested Traffic	27%	33%	42%	55%
Bad Weather	23%	25%	33%	53%

Note: Respondents were asked about "If all vehicles had level X automated technologies, how likely would crashes caused by the following behaviors be prevented?" for each level of AV technology.

Table 4. Concerns about AV Technologies (Extremely or Very)

Potential Concerns	Level 2	Level 3	Level 4	Level 5
Technology Malfunction	61%	66%	71%	75%
Over-Reliance	53%	62%	66%	71%
No Hands-on Control	42%	53%	58%	70%
Purchase Price	56%	61%	66%	72%
Vehicle Hacking	50%	58%	63%	68%
Data Privacy	45%	49%	52%	57%
*Distraction/Annoying**	36%	41%	49%	NA
*Confusion on How/When to Use**	34%	43%	45%	NA

* surveyed only pertaining to levels 2 to 4

Note: Respondents were asked "Please rate the following potential concerns of Level X automated vehicle technology" for each level of AV technology.

REFERENCES

AAA Foundation for Traffic Safety (2018). 2017 Forum on the Impact of Vehicle Technologies and Automation on Users: A Summary Report. Washington, D.C.: AAA Foundation for Traffic Safety. Available: https://aaafoundation.org/wp-content/uploads/2018/02/2017-Utah-Forum-Summary-Document-FINAL.pdf

AAA Foundation for Traffic Safety (2019). 2018 Forum on the Impact of Vehicle Technologies and Automation on Vulnerable Road Users and Driver Behavior and Performance: A Summary Report. Washington, D.C.: AAA Foundation for Traffic Safety. Available: https://aaafoundation.org/wp-content/uploads/2019/01/2018-AAAFTS-Iowa-Forum-Summary-Report-FINAL.pdf

AAA Foundation for Traffic Safety (2019). 2018 Traffic Safety Culture Index. Washington, D.C.: AAA Foundation for Traffic Safety. Available: https://aaafoundation.org/wp-content/uploads/2019/06/2018-TSCI-FINAL-061819_updated.pdf

Benson, A., Tefft, B.C., Svancara, A. M. & Horrey, W., (2018). Potential Reduction in Crashes, Injuries and Deaths from Large-Scale Deployment of Advanced Driver Assistance Systems. *AAA Foundation for Traffic Safety.*

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. Transportation Research Part A: Policy and Practice, 77, 167-181.

GfK (2016). KnowledgePanel® Design Overview. Palo Alto, CA: GfK. Available: https://www.gfk.com/fileadmin/user_upload/dyna_content/US/documents/GfK_KnowledgePanel_Overview.pdf

Levin, S., & Wong, J. C., (2018). Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian. *The Guardian.* Available: https://www.theguardian.com/technology/2018/mar/19/uber-self-driving-car-kills-woman-arizona-tempe

McDonald, A., Carney, C. and McGehee, D.V., (2018). Vehicle Owners' Experiences with and Reactions to Advanced Driver Assistance Systems. *AAA Foundation for Traffic Safety.*

Noy, I. Y., Shinar, D., & Horrey, W. J. (2018). Automated driving: Safety blind spots. Safety science, 102, 68-78.

Sivak, M., & Schoettle, B. (2015). Road safety with self-driving vehicles: General limitations and road sharing with conventional vehicles.

Strayer, D.L., Cooper, J.M., Goethe, R.M., McCarty, M.M., Getty, D. & Biondi, F., (2017). Visual and Cognitive Demands of Using In-Vehicle Information Systems. *AAA Foundation for Traffic Safety.*

Zmud, J. P., & Reed, N. (2019). Synthesis of the Socioeconomic Impacts of Connected and Automated Vehicles and Shared Mobility. In Transportation Research Board Conference Proceedings (No. 56).

ABOUT THE AAA FOUNDATION FOR TRAFFIC SAFETY

The AAA Foundation for Traffic Safety is a 501(c)(3) nonprofit, publicly supported charitable research and education organization. It was founded in 1947 by the American Automobile Association to conduct research to address growing highway safety issues. The organization's mission is to identify traffic safety problems, foster research that seeks solutions and disseminate information and educational materials. AAA Foundation funding comes from voluntary, tax-deductible contributions from motor clubs associated with the American Automobile Association and the Canadian Automobile Association, individual AAA club members, insurance companies and other individuals or groups.

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