



PUBLIC PERCEPTIONS OF CONNECTED AND AUTOMATED VEHICLE TECHNOLOGIES

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Public Perceptions of Connected and Automated Vehicle Technologies

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Abstract:

This report investigates the public perceptions of connected and automated vehicle (CAV) technology. The results of this research stem from a series of interviews with test drivers who participated in a connected vehicle V2I demonstration and from a web-based survey aiming at the general U.S. population. In general, participants had mostly positive impressions of CAVs, recognized many of their benefits, and were interested in using these new vehicle features. Respondents also expressed several concerns, including those related to trust, with these applications and were not willing to pay substantially more to own a vehicle equipped with these new technologies.

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EXECUTIVE SUMMARY

Connected and automated vehicle (CAV) technology is one of the fastest-growing technological fields of the automotive industry in recent years. In order to identify the best path forward for this technology, it is important to understand how drivers perceive it.

Building upon previous work conducted in 2012, the Center for Automotive Research (CAR) further explored and assessed public perceptions toward CAV technology.

CAR designed its research taking into consideration several prior initiatives aiming at understanding how drivers perceive and use CAV technology. In 2011 and 2012, the USDOT conducted a series of driver acceptance clinics (DACs) in order to obtain feedback on connected vehicle technology and safety applications. One most important results of this effort was that test drivers exposed to V2V safety features were overwhelmingly positive about the technology. In 2013, as part of the Connected Vehicle Safety Pilot program, test drivers completed a survey on their impressions. The drivers indicated that some technologies, such as Blind Spot Warning / Lane Change Warning (BSW/LCW) seemed more effective and were more desirable than other safety warnings that were tested. Drivers were generally resistant to the idea of sharing personally identifiable location data with third-party organizations. In 2014, NHTSA received public comments linked to an advance notice of proposed rulemaking (ANPRM) regarding a potential V2V mandate for new light vehicles. The majority of public comments were in opposition to a potential V2V mandate for new light vehicles.

The CAR team conducted a connected vehicle V2I demonstration in the Detroit connected vehicle test bed with six people unexperienced with CAV technology. After the demonstration, CAR interviewed the participants on their perceptions of the technology, including trust and interest in using it. All the participants described the experience as “interesting,” or similarly. The subjects were generally enthusiastic about the Signal Phasing and Timing (SPaT) application, but had doubts about its real-world suitability. The participants were also highly positive about the prospect of V2V for safety. In addition, they were generally positive about the possibility of a USDOT mandate for V2V connectivity. The participants also discussed their concerns linked to the immature state of technology, data privacy, and cost. Finally, subjects were asked about the role of the state government. A general theme in the responses was that the state had an important role to play in promoting

advanced automotive technologies for safety, mobility, and economic development.

The CAR researchers used the information gleaned to design a web-based survey to gather quantitative data on the perceptions of the U.S. population of CAV technology. The participants were asked about their impressions, experience, interest, and confidence in CAV technology, as well as about the benefits and concerns with CAV. The sample of 114 respondents represented a population that was older, more educated, and wealthier than the average U.S. citizen. The results of the survey are generally encouraging. A solid majority of respondents (59 percent) have very positive or somewhat positive impressions of CAV technology. The two age groups most likely to have a generally positive impression of the technology were the 18-29 years and the 45-59 years groups. Women had a better impression of CAV than men. Not surprisingly perhaps, more educated participants had a better defined and somewhat polarized opinion of CAV. Finally, the lower the household income of the participants, the more negative the impression of CAV technology.

More than 60 percent of the participants had direct experience with Back-up Assistance. However, they had limited experience with most of the technology mentioned in the survey (Parking Assistance, Lane-Keeping Assistance, Lane Departure Warning, Forward Crash Warning/Automatic Emergency Braking, Blind-Spot Detection, Adaptive Cruise Control, Connected Technology).

On the other hand, participants manifested a substantial interest in using CAV applications. The most appealing technology was Blind-Spot Detection. Back-up Assistance and Forward Crash Warning/Automatic Emergency Braking were also popular. The least popular application was Lane-Keeping Assistance. Lane Departure Warning, Forward Crash Warning, and Blind-Spot Detection were particularly interesting for the participants in the age ranges 18-29 and 45-59. Participants between 18 and 29 years were the most likely group to be interested in Lane Keeping Assistance, Adaptive Cruise Control, and Parking Assistance. Back-up Assistance was deemed interesting to the greatest extent by participants between 45 and 59 years, and by a large margin. Finally, the 30-44 age category was the group that expressed the most interest in connected technology.

Despite having generally positive impressions of CAV technology, half of respondents showed little-to-no interest in owning or leasing a self-driving vehicle. The youngest age group (18-29 years) was the most interested in fully autonomous vehicles.

For the participants in this survey, the biggest benefit of CAV technology was increased safety. Other benefits that were important for the respondents were improved emergency response to crashes, lower insurance rates, and parking and back-up assistance. Some perceived benefits were correlated with age, whereas others were not. Respondents aged 18 to 29 selected the ‘parking / back-up assistance’ and ‘improved emergency response to crashes’ options the most. The 30-44 age group believed the strongest that one of the top CAV benefits is represented by lower insurance rates. Participants under 45 years were most likely to mention lower vehicle emissions and less traffic congestion. Finally, participants over 45 years were more convinced than their younger counterparts that CAV would increase vehicle safety.

Respondents were asked to list their top three concerns with CAV technology. Cost proved to be the highest concern, followed by cyber-security, driver complacency, and product failure/error. The 18 - 29 years age group was the most concerned with cyber-security. However, product failure was significantly less of an issue for this category of respondents. Thirty to forty-four years old participants were by far the group most concerned with system performance in poor weather. Driver distraction was more of a concern for participants under 45 years, than for older participants. Finally, older participants, specifically those over 45 years, were relatively more concerned with driver complacency than the younger respondents were.

Given that the cost of CAV features was one of the primary concerns for the survey participants, it is not surprising that, in general, respondents were not willing to pay much more in order to have these features on a vehicle. In fact, more than a third of respondents stated they would pay less than \$500 in addition to the cost of a new vehicle. Overall, compared to women, men were willing to pay less for CAV features. Finally, the analysis by age revealed that the 30-44 years age group was the most reluctant to pay additionally for CAV features.

Respondents also were asked several questions that addressed their general confidence or their comfort level with CAV systems. When asked whether, in the event of an imminent crash, a driver would prefer the vehicle alert him/her of the situation or the vehicle actively taking control of the vehicle, respondents’ answers were fairly even. In addition, just over half of respondents either somewhat or strongly disagreed with the statement ‘I trust that a computer can drive my car with no assistance from me.’ Participants between 18 and 29 were least likely to trust self-driving technology. Another question was about the statement ‘I would be comfortable entrusting the

safety of a close family member to a fully automated car,' to which, once again, more than half of the participants somewhat or strongly disagreed. The youngest participants (18-29 years) were only half as willing to entrust a family member to self-driving vehicle compared to the other older participants; their views were less polarized than those of the other respondents. Finally, concerning their comfort with data-sharing, two times more participants were strongly opposed (22 percent) to transmitting data to surrounding vehicles (V2V) than those that were strongly in favor (11 percent) of doing so. The older the participants, the less they were comfortable with sharing data.

Almost four in five respondents were not aware that Michigan, Nevada, California, and Florida had already passed laws regarding the testing, operation, and sale of fully automated vehicles within the respective states. These results show that public knowledge of state legislation on autonomous driving is limited. Concerning the support for government-imposed requirements to make crash avoidance technology mandatory, forty-three percent of respondents somewhat or strongly supported the idea.

The results of this research project show that public perceptions of CAV technology are dynamic, complex, and hold deep transportation policy implications. It is therefore important to renew this type of research every one or two years in order to identify changes and constants in public perceptions.

Developing a short publication for the MDOT website based on some of the most interesting and important results of the survey would increase the visibility of this topic. In addition, it would be worthwhile to consider other outreach channels for the greater public for the results of this study (e.g., media, conferences, etc.), to improve the dissemination of information towards the Michigan population. As the results of the survey showed, public knowledge of state legislation on autonomous driving is limited. Finally, the results of this research could be disseminated within MDOT, to maximize their potential to inform transportation policy.

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1 INTRODUCTION

Connected and automated vehicle (CAV) technology is one of the fastest-growing technological fields in the automotive industry. The technology offers numerous benefits – from safety to efficiency – yet some consumers have concerns the technology will affect their privacy, for example.

To identify the best path forward for CAV technology, automotive and transportation system engineers and policy leaders must understand how drivers perceive it. Building upon previous work conducted in 2012, the Center for Automotive Research (CAR) further explored and assessed public perceptions toward CAV technology. These developments were informed by a thorough understanding of what the public will support and which concerns need to be addressed.

To accomplish this task, the CAR team conducted a multi-faceted study composed of several distinct, but related, efforts.

First, the team performed a thorough literature review of available information on public perceptions of the technology that builds upon CAR work from 2012.

Second, researchers used this information gleaned to produce a web-based survey to gather quantitative data from 100 drivers, including both respondents experienced with CAV technology and those not experienced.

Third, the CAR team conducted a more in-depth study of five to ten drivers with no experience using CAV technology. Those selected drove a vehicle (on roads, test tracks, or both) equipped at least with connected vehicle technology (and automated if possible); afterwards, the CAR team interviewed them regarding their perceptions of the technology, including trust and interest in using it.

The report that follows presents findings from the literature review, survey, and test driver interviews. CAR also recommended a public communication plan for MDOT that focuses on positive perceptions of CAV technology.

2 LITERATURE REVIEW

CAR performed a literature review of the latest relevant initiatives in understanding the perceptions of drivers concerning connected and automated vehicle technology. This section highlights the most important conclusions of these initiatives.

2.1 USDOT DRIVER ACCEPTANCE CLINICS

In 2011 and 2012, the USDOT in cooperation with the Crash Avoidance Metrics Partnership (CAMP), Virginia Tech Transportation Institute (VTTI), and others, conducted a series of driver acceptance clinics (DACs) in order to obtain feedback on connected vehicle technology and safety applications from a representative sample of drivers. The clinics evaluated a total of 688 typical drivers with no prior experience with connected vehicle technology, evenly distributed between male and female, and across a range of ages. There were six different types of safety features provided across the test vehicles:

- Forward Collision Warning (FCW): Warns drivers if they are approaching a stopped or slower lead vehicle
- Emergency Electronic Brake Light (EEBL): Warns the driver that a lead vehicle is braking hard
- Intersection Movement Assist (IMA): Alerts the driver to cross-traffic at an intersection¹
- Blind Spot Warning/Lane Change Warning (BSW/LCW): Alerts drivers to vehicles in their blind spot when they initiate a lane change
- Left Turn Assist (LTA): Alerts driver to oncoming traffic when making a left turn at an intersection across a lane of traffic²
- Do Not Pass Warning (DNPW): Warns driver of oncoming traffic on a two-lane roadway

Test subjects drove vehicles equipped with connected vehicle technology and one or more of the safety features listed above. Following the test-driving event, subjects were given an exit survey and participated in a focus group.

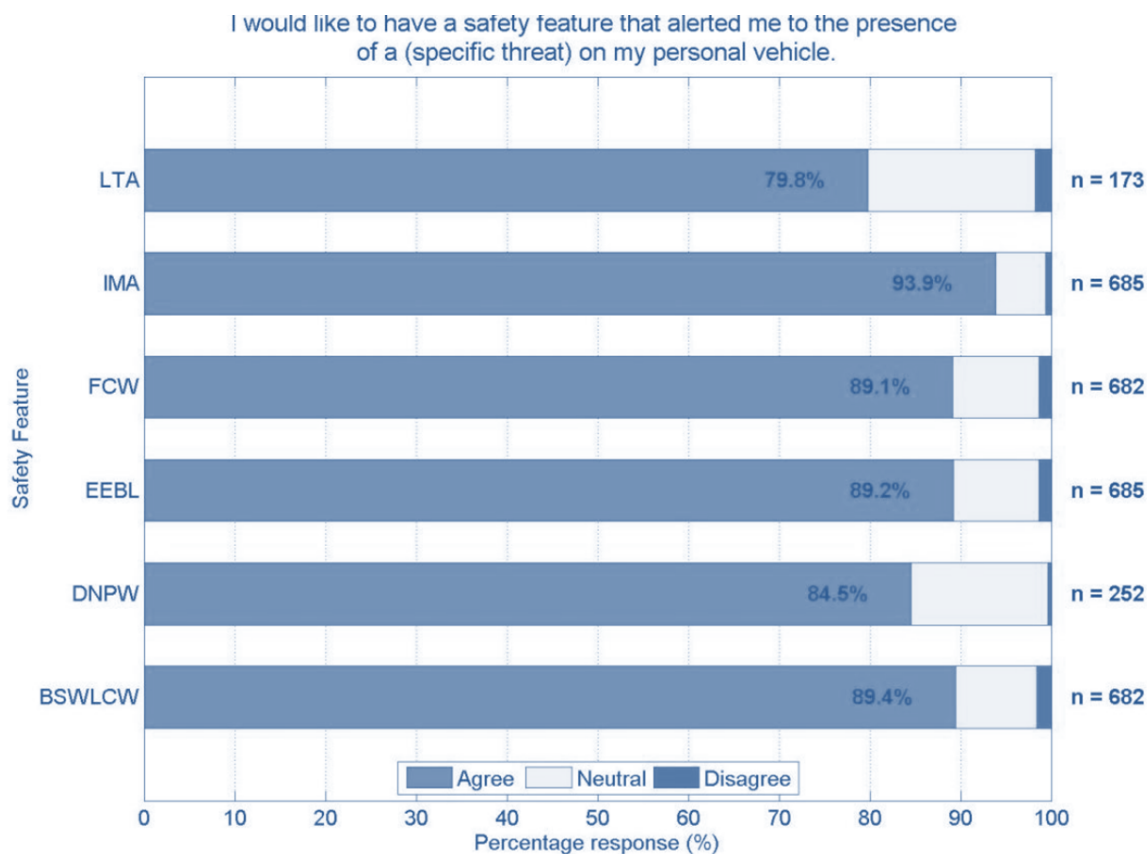
¹ IMA is one of the two safety features analyzed in depth in the NHTSA V2V ANPRM.

² LTA is one of the two safety features studied in depth in the NHTSA V2V ANPRM.

One big-picture result of the DACs is that test drivers exposed to V2V safety features in such a controlled environment were overwhelmingly positive about the technology. Subjects were asked to rate on a 1-7 Likert scale their agreement with the statement, “I would like to have Vehicle-to-Vehicle Communication on my personal vehicle.” Over 90 percent of subjects rated this statement a six or seven, indicating strong agreement and desire to adopt the technology.³

There was strong desire for connected vehicle technology across each individual safety feature, as shown in Figure 1.

FIGURE 1: DRIVER ACCEPTANCE CLINIC SUBJECT REPORTING OF DESIRABILITY OF SAFETY FEATURE IN PERSONAL VEHICLE⁴



DACs participants discussed concerns with the technology such as cost, lagging adoption, and over-reliance on the system. However, participants perceived the benefits of the technology to far outweigh potential drawbacks.⁵

³ Lukuc 2012.

⁴ Lukuc 2012, pp. 17.

⁵ Lukuc 2012, pp.31.

2.2 CONNECTED VEHICLE SAFETY PILOT DRIVER SUBJECTIVE DATA

A summary and analysis of driver subjective data collected from volunteers in the Safety Pilot Model Deployment in Ann Arbor, titled “Preliminary Analysis of the Driver Subjective Data for Integrated Light Vehicles,” reports on the results of an exit survey given to subjects who drove CAMP-provided integrated vehicles for six months. Eight OEMs participated in the connected vehicle safety pilot, each providing eight vehicles with integrated DSRC-based safety features. Table 1 shows what safety features were included in each of the OEM-provided integrated light vehicles.

TABLE 1: SAFETY FEATURES PROVIDED IN INTEGRATED CAMP VEHICLES, BY OEM

OEM	FCW	EEBL	IMA	BSW/LCW	LTA	DNPW
Ford	✓	✓	✓	✓		✓
GM	✓	✓	✓	✓		✓
Honda	✓	✓	✓	✓		✓
Mercedes	✓	✓	✓	✓		
Toyota		✓	✓	✓		
Hyundai	✓			✓		
Nissan	✓			✓	✓	
VW-Audi	✓	✓	✓			

The specific design of the safety feature was not standardized for the pilot project—each OEM was free to determine how DSRC safety features were to be integrated into the vehicle. This is important to consider because it complicates analysis of the subjective data provided by the drivers, as drivers of different vehicles had different subjective experiences across a single safety feature. For example, while 56 vehicles were fitted with FCW, each OEM provided a unique approach to determining when and how the driver should be alerted (as in the example shown in Figure 2).⁶

⁶ Figure 2 photo source: <http://www.scientificamerican.com/slideshow/michigan-car-crash-test/>

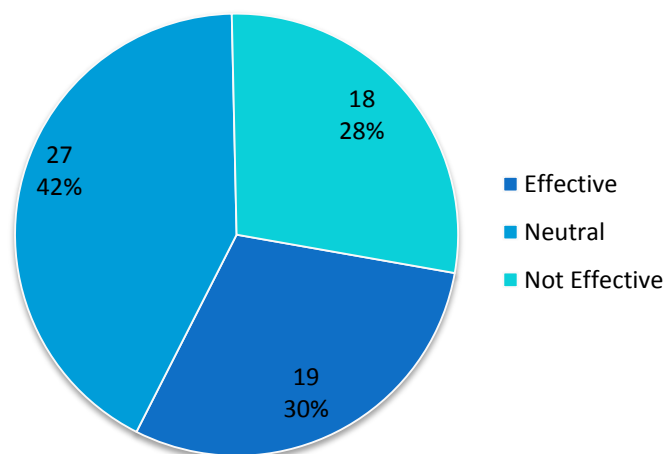
FIGURE 2: EXAMPLE OF DRIVER INTERFACE IN INTEGRATED LIGHT VEHICLE (FCW VISUAL IN CENTER STACK)



USABILITY/EFFECTIVENESS

Subjects were asked how effective the warnings were at alerting them to the presence of potential conflicts. The responses were measured on a 1-7 Likert scale. Responses of one or two were classified in the report as “not effective.” Responses of three, four, or five were classified as “neutral.” Responses of six and seven were classified as “effective.”

FIGURE 3: SAFETY PILOT DRIVER SUBJECTIVE OVERALL RATING OF WARNING EFFECTIVENESS

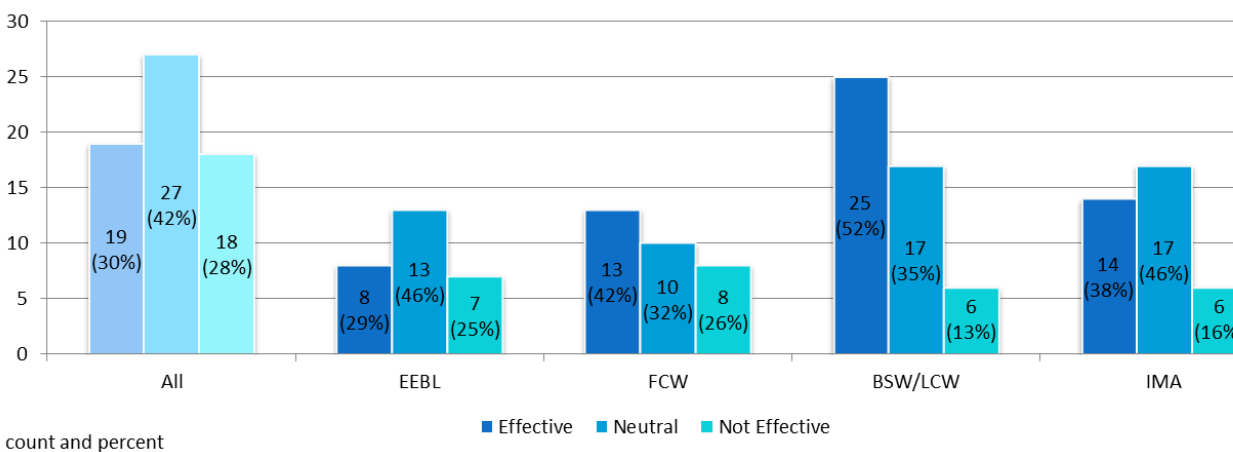


count and percent; n=64

As shown in Figure 3, there was not a strong conclusion regarding drivers' perceived effectiveness of the warnings. Nineteen of the 64 test drivers rated the warnings as effective. Eighteen described the warnings as not effective. More frequently, drivers were in the neutral range when describing the

effectiveness of the warning systems; twenty-seven drivers rated the effectiveness as three, four, or five on a one to seven scale. Figure 4 provides a breakdown of driver subjective ratings of warning effectiveness for individual safety features.⁷

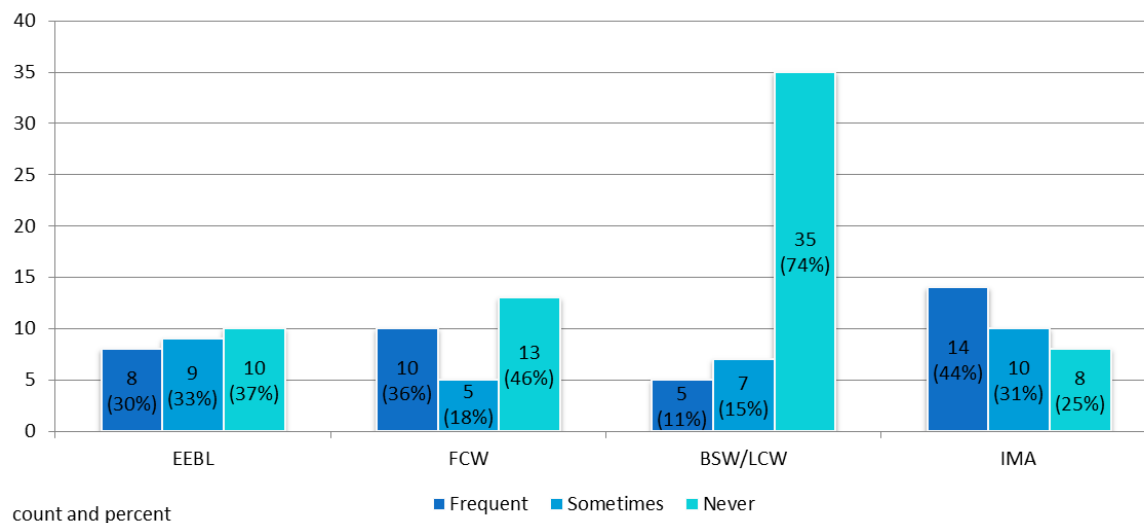
FIGURE 4: SAFETY PILOT DRIVER SUBJECTIVE RATINGS OF WARNING EFFECTIVENESS



As shown in Figure 4, drivers tended to perceive BSW/LCW as the most effective of the safety features. Over half of drivers rating BSW/LCW reported the warnings as “effective.” The tendency of drivers to rate BSW/LCW as more effective than other features is likely related to the perceived failure rate of the warning systems. Drivers were asked how often they received alerts that were “incorrect (no danger present).” The reported frequency of incorrect warnings is provided in Figure 5.

⁷ The report did not include statistical analysis of LTA and DNPW due to the relatively lower number of vehicles equipped with each feature. The total number of drivers rating each safety system does not directly reflect the amount of drivers testing each system. Many respondents did not answer questions about specific safety features because “they believed they had received no alerts, and were likely unaware or unclear regarding the specific systems featured in their particular test vehicle. Another complicating factor is that some of the vehicles had sensor-based warning systems—possibly confusing respondents about which warning systems they were being asked about.

FIGURE 5: SAFETY PILOT DRIVER SUBJECTIVE RATINGS OF INCORRECT WARNING FREQUENCY



As shown in Figure 5, only eleven percent of drivers rating BSW/LCW reported receiving frequent incorrect alarms, and three-quarters of drivers reported “never” receiving incorrect warnings. By contrast, over half of drivers rating EEBL, FCW, and IMA perceived that they were frequently or sometimes receiving incorrect warnings. Surprisingly, drivers’ perception of incorrect warnings was not correlated to actual performance of the warning systems. Drivers generally perceived the warning systems to be more effective than objective performance measurement of the system.⁸

Drivers were also asked about the potential for the system to be distracting. Sixteen percent of drivers were worried about this possibility. Most drivers reported that the connected vehicle system was no more distracting than a car radio. Drivers were also not concerned about becoming over-reliant on the system, though in some cases this may be because the drivers do not perceive the system as accurate enough to be relied upon.⁹

SECURITY AND PRIVACY

To gauge concern for privacy, subjects were asked, “how willing would you be to have connected vehicle technology on your vehicle that, when combined with other information may allow [a third-party organization] to learn about

⁸ As measured by researchers, the mean false alert rate over all vehicles was 67 percent. Only eight (13 percent) of test drivers received more correct alerts than false alerts (Stevens 2013, pp. 33-34).

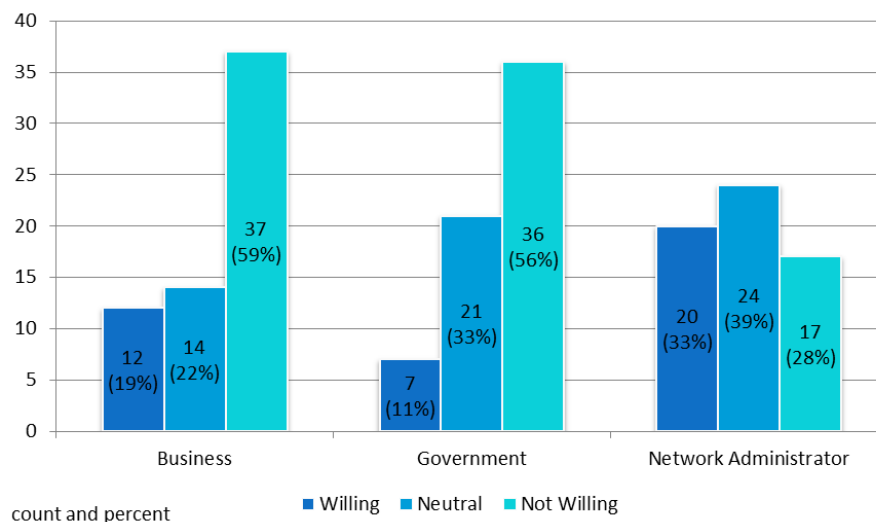
⁹ Stevens 2013, pp. 39.

your driving behavior and patterns.” Specific third-party organizations that were mentioned in particular included:

- “A business entity to learn about your vehicle’s location and travel patterns.”
- “The government to learn about your driving behavior and patterns.”
- “Appropriate personnel to determine criminal behavior such as hacking.” (This would be equivalent to a network administrator.)

As shown in Figure 6, drivers were generally resistant to the idea of sharing personally identifiable location data with third-party organizations.

FIGURE 6: SAFETY PILOT DRIVER WILLINGNESS TO SHARE DATA



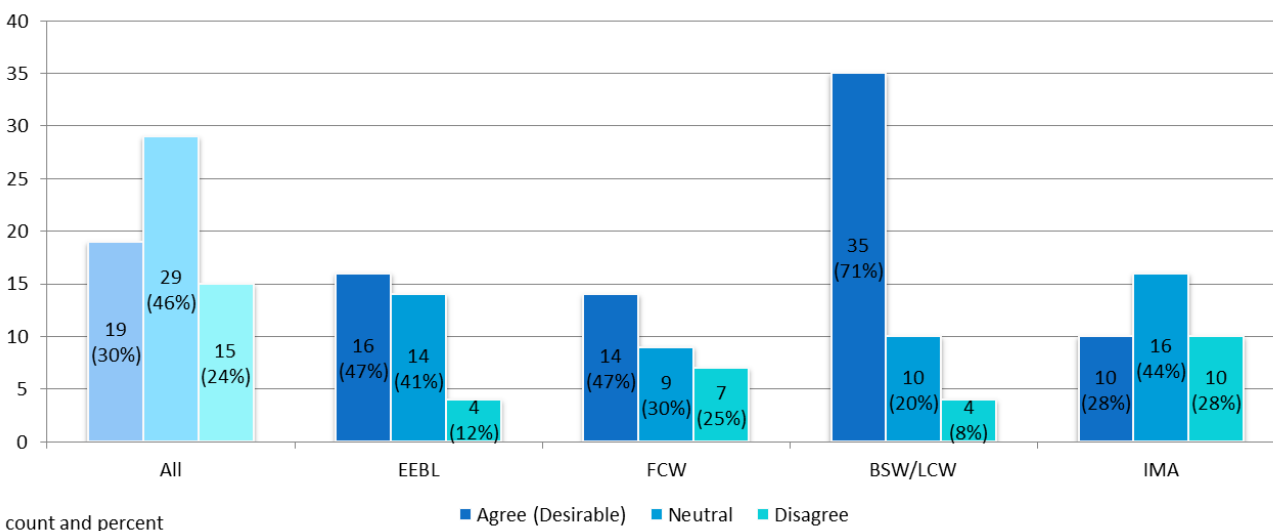
More than half of drivers reported being not willing to share data with business or government entities. Drivers were slightly more willing to have location data available to an entity for purposes of network security and administration (i.e., to prevent “hacking”). Perhaps surprisingly, “younger” drivers aged 20-30 were *less* likely to report willingness for third-party entities to access personally identifiable location data for any reason.¹⁰

¹⁰ Stevens 2013, pp. 32.

DESIRABILITY

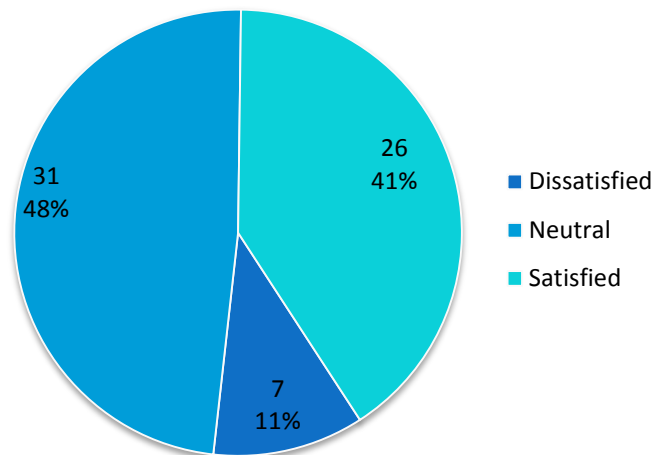
Test drivers were asked to rate their agreement with the statement, “I would like to have [this warning] on my personal vehicle,” on a 1-7 Likert scale. Responses of one or two were classified in the report as disagreement, or *not* wanting the system. Responses of three, four, or five were classified as “neutral.” Responses of six and seven were classified as agreeing with the statement that the system was desirable. The results are shown in Figure 7.

FIGURE 7: SAFETY PILOT DRIVER SUBJECTIVE DESIRABILITY OF WARNING SYSTEMS



As shown in Figure 7, BSW/LCW was rated as the most desirable warning feature, and the only system that more than half of respondents reported as wanting in their personal vehicle. The “All” column in Figure 7 is not a summary of individual systems, but the result of test drivers being asked about the connected vehicle warning suite as a whole. Desirability of the system as a whole was reported by 30 percent of drivers, closely tracking with desirability of IMA, the individual warning system rated least desirable.

FIGURE 8: SAFETY PILOT DRIVER SUBJECTIVE RATING OF SYSTEM SATISFACTION



count and percent; n=64

Similarly, drivers were asked about their general satisfaction with the connected vehicle system. “Overall satisfaction” with the connected vehicle system was mostly neutral, with 41 percent satisfied, 48 percent neutral, and 11 percent dissatisfied (see Figure 8).

After rating general satisfaction with the connected vehicle system, respondents were asked, “Why” and allowed an open-ended response. In general, those who gave high scores praised the increase in situational awareness they attributed to the alerts. Those who gave low scores felt they received too few valid alerts or too many false alerts. Select responses are provided below. Drivers who were *satisfied* with the system provided responses such as:

“I became more aware of driving situations that could cause a warning.”

“The few times it went off I found it helpful.”

“A few false alarms, but besides that I was completely satisfied.”

“If there were more cars with the system, that would be a huge incentive. I mainly got to see ‘phantom’ cars in the monitor—it was fun to see who was participating.”

Nearly half of drivers rated “neutral” satisfaction with the system, rating it a three, four, or five on a 1-7 Likert scale. These drivers provided explanations such as:

“Even when I saw no clear reason for the alarm, at least it made me more alert.”

“If you could get the FCW to work correctly, I would take it up to a seven [satisfied].”

“Overall a good concept, if proven. Downside is that if every car has this technology then warnings will go off every minute.”

“Potential was good, execution not so good—could be because there are not enough transmitter cars.”

“I feel that it went off just because another connected vehicle was close to my car.”

“I would only pay for the system if I could turn off warnings and all traffic signals were equipped with technology that knew I was there.”

Only seven drivers reported general dissatisfaction with the connected vehicle system. These drivers provided such explanations as:

“False alarms 99% of the time.”

“Way too much going on the dashboard display. Too many distractions already on the [vehicle].”

“Intersection alert was annoying when on highway or when at a complete stop.”

“Car display was nice, but if it showed all cars on road it would be excessive.”

“It did not work for me.”

The preliminary report notes the discrepancy between the reported desirability of connected vehicle systems in the 2011-2012 Driver Acceptance Clinics and the Connected Vehicle Safety Pilot. It is likely that the controlled environment of the DACs, drivers perceived the warnings as more appropriate and accurate as compared to the real-world driving experience of the Safety Pilot Model Deployment.¹¹

¹¹ Stevens 2013, pp. 39-41.

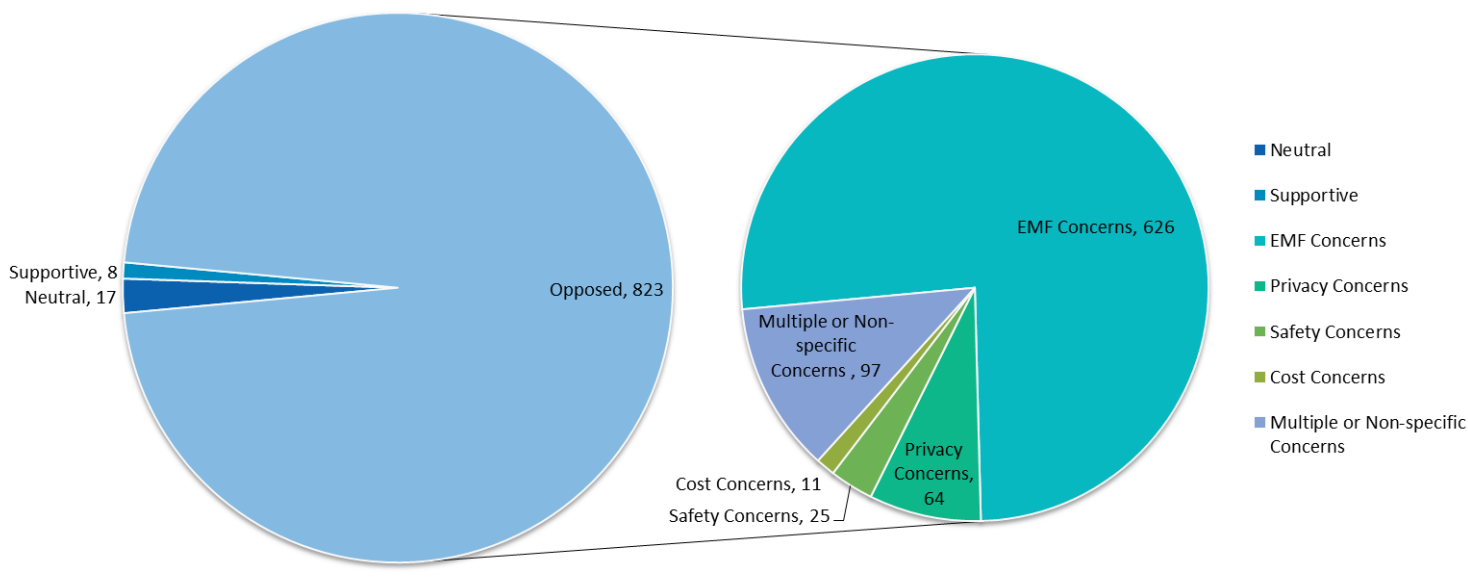
2.3 NHTSA V2V ANPRM PUBLIC COMMENTS

In August of 2014, NHTSA published an advance notice of proposed rulemaking (ANPRM) regarding a potential V2V mandate for new light vehicles. The ANPRM invited public comments on connected vehicle technology and the potential mandate. A total of 937 comments were posted to the federal register. Many of these comments were from corporate interests, government agencies, or experts associated with such entities. But the majority of comments (848) were from individuals with no obvious affiliation with the connected vehicle program.

Due to the unstructured nature of the public comment forum, the comments are not expected to reflect the sentiment of the general population. However, these comments do offer a rare opportunity for qualitative insight into the sentiments and concerns that the public may have regarding V2V.

The majority of public comments (823) were submitted in opposition to a potential mandate.¹² Of the remaining comments, eight were submitted in support of a mandate, and 17 were neutral (Figure 9). Most of the comments in opposition to the potential V2V mandate can be categorized by the primary point of opposition, as detailed in the following discussion.

FIGURE 9: SENTIMENT ANALYSIS OF PUBLIC COMMENTS TO NHTSA V2V ANPRM¹³



¹² While this accounts for over 97 percent of the total comments, this does not directly reflect the sentiments of all commenters because individuals are able to submit multiple comments.

¹³ Comments submitted by corporate, government, and institutional interests, as well as individuals associated with such interests, are not considered in this analysis.

ELECTROMAGNETIC FIELD (EMF) RADIATION CONCERNS

Most comments expressed concern over the risks of increased exposure to electromagnetic field (EMF) radiation emitted by wireless devices.¹⁴ The ANPRM comments highlight the existence of a community of people who generally believe that EMF radiation is a health hazard, particularly for those with a condition known as ‘electrosensitivity’ or *electromagnetic hypersensitivity* (EHS). While the diagnosis of EHS is controversial, many comments submitted in opposition to the V2V mandate maintain that EHS severely impacts their lives, and that a V2V mandate may make it practically impossible to travel on public roads. Symptoms of EHS may include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances).¹⁵

EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure. Further, EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem.¹⁶ Nevertheless, there is a significant and engaged community of people across the globe who oppose the continued proliferation of artificial EMF transmission. This community has been actively opposing technologies such as public Wi-Fi and utility smart meters, and was well-represented in opposing a possible mandate of V2V. Some typical comments are given as examples, below.

“There are many studies on the negative health effects of people being constantly exposed to wireless devices. Electromagnetic hypersensitivity is now on the rise and requiring wireless communications in cars will only add to current problems.”

¹⁴ Many comments classified in this study as primarily concerning EMF radiation also cited privacy, safety, and cost issues as concerns. However, in most cases it was evident that the primary motivation for submitting a comment to the federal register was concern of EMF radiation. Comments that did not clearly indicate a primary/motivating concern were categorized as “multiple/non-specific.”

¹⁵ WHO 2006.

¹⁶ WHO 2006.

“The safety of EMFs and wireless technologies has simply been assumed, without solid, long-term scientific proof for such assumptions. On the contrary, there is proof that they cause many problems, including damage to DNA. For years leaded gas and asbestos were thought to be safe, yet this turned out to be false. The idea of Vehicle-to-Vehicle Communications makes the same potentially harmful assumption.”

“Please wait until real scientific proof exists for the safety of Vehicle-to-Vehicle Communications before requiring them.”

“I live in the National Radio Quiet Zone because I am a technological leper.”

“PS. My computer is hardwired and allows me to function with the Internet.”

“In 2011 The World Health Organization (WHO) classified low level, non-thermal radiofrequency radiation, like the kind used in the NHTSA proposal, as a class 2B possible carcinogen, in the same category as DDT and lead. In addition the WHO makes it very clear in their 2010, WHO Research Agenda for Radiofrequency Field that the scientific research on how radiofrequency radiation affects children has not been completed and that the current research is pointing to harmful adverse affects.”

“Requiring V2V technology violates the 2008 ADA Amendments since it will further isolate and marginalize many people with radiofrequency sickness, electromagnetic hypersensitivity, etc”

“My 10 yr. old daughter has electromagnetic hypersensitivity, which means that she can no longer attend public schools since we discovered last year that her elementary school's Wi-Fi was making her sick.”

“Our daughter is fighting Leukemia now. EMF has been linked to Leukemia and many other cancers and there is a lot of research to prove that.”

“As the numbers of EMF refugees continue to grow, we should be asking ourselves what might happen to whole populations in the future should the proliferation of wireless radiation continue unabated.”

“I feel like we may look back in 20 years with more knowledge and compare EMF exposure to smoking before we knew it was unhealthy.”

“It is a Human Rights Violation to enforce more EMF radiation, more pain and suffering, onto humanity and all Life on Planet Earth. There are people having to abandon their homes they've created and are now EMF Refugees. I weep.”

“Cars do not need to talk to each other. I do not want nor need such a device in my car. We are strongly opposed to any attempts to make wireless devices mandatory for the public.”

PRIVACY CONCERNS

Sixty-four public comments focused on concerns over privacy rights and civil liberties.¹⁷ A minority of privacy-concerned comments focused on the possibility of individual hackers or corporations tracking them. However, most commenters were concerned about the ability of government to track their vehicles. Some typical comments are provided below.

“V2V is an invasion of our privacy and our freedom. Big corporations like Google want this technology to become mandatory to further their goal of monopolizing the transportation industry with autonomous vehicles.”

“My first concern is the privacy and freedom of the individual owners. It seems way too Orwellian for a government identity to be able to track every citizen. ... It is very hard to fathom why this is so very needed. Is there more deaths because of left turns or in intersections than heart attacks or cancer? In my opinion the money and effort would be better placed somewhere else.”

“Highway Safety is a ruse for increased tracking of the American Public. Indeed, the per cent gained in highway safety (estimated at 3%) is negligible compared to the immeasurable loss of personal privacy.”

¹⁷ This total does not include several comments that centered a civil liberty argument around the desire to be free from EMF radiation. These commenters generally argued that a government mandate for connectivity would be violating their rights by forcing something that would impair their health and wellbeing. Such comments were classified as “EMF Radiation Concerns.”

“This is one more invasion of our privacy by the Federal Government.”

“I strongly oppose this rule. This is contrary to the rule of privacy guaranteed by our Constitution. We cannot give up everything to make law enforcement's work easier.”

“I would be much more convinced of privacy protection if you hired a bunch of hackers to try to break it than by all the Public Service Announcements about how much it protects our privacy. You guys are regulators, not tech gurus or hackers.”

“It will be an invasion of privacy no matter what you promise (promises by government officials are COMPLETELY worthless, even if their intentions are good).”

“Some rogue agency like the NSA or the CIA will collect and analyze it at will in the name of safety all while bending our privacy rights into various painful contortions. I have a constitutional right to privacy and liberty and I value those over safety every day of the week.”

“Yes, this system might save some lives. But give me liberty or give me death! My car should be my private domain, as an individual I should have the RIGHT not to install a communication device on my own car.”

“Driving habits and patterns are among the most intimate details of a person's life. To adopt a cliché, you are where you drive.”

“I believe that while V2V communications can serve to save lives it presents an added threat to personal privacy and security of personal information. I would imagine that the systems that would allow for this type of communication would also save data such as location and tendencies of the driver. If this is true it would leave the vehicle systems susceptible to hacking and acquisition of this information which can be useful to the hacker in planning a home break-in or getting the usual locations of the car which would allow for harassment and following of individuals.”

SAFETY CONCERNS

The twenty-five comments identified as primarily concerned with safety focused on some perceived increased risk of crashing due to V2V technology.

Many commenters were concerned that the technology could become a distraction. Others believe that drivers could become over-reliant on V2V warnings and not be appropriately vigilant in cases where the technology does not work. A few comments focused on the concern that hackers or system failure could cause havoc.

“the V2V will be much more of a hazard to motorists and the general public than not having the device. The use of this new technology will only prove to remove instinctive caution when operation a motor vehicle. Too many people now rely on technology to tell them what to do and when that it is creating a situation where people no longer think for themselves, and they do not take precautions they ordinarily would if they did not rely on a device to tell them what to do.”

“Technology this comprehensive is downright dangerous. If somebody hacks into it, or it experiences a malfunction, terrible consequences would ensue.”

“We want our family members to pay attention to the road, not all the gadgets that distract them from driving safely. AND, we would like other drivers to do the same.”

“What if this info is inaccurate? What if bad people falsify data to cause crashes?”

COST CONCERNS

Concerns over the cost of the system were very small compared to other concerns. Eleven comments were mainly focused on the escalating cost of vehicles. A few comments broadly related the cost of new vehicles to regulatory mandates. Cost concerns were generally minor compared to other issues.

MULTIPLE OR NON-SPECIFIC CONCERNS

Comments were included in this category if there was no clear primary issue that motivated the individual to submit the comment. In some cases, comments in this category listed multiple reasons to be opposed to the mandate with no issue clearly most important to the commenter. In most cases, the comments in this category did not specify any reason for opposition, or stated a general opposition to regulatory activities.

3 CONNECTED VEHICLE EXPERIENCE INTERVIEWS

CAR and Leidos hosted a connected vehicle V2I demonstration in the Detroit connected vehicle test bed. The test vehicle utilized for the demonstration was equipped with a DSRC enabled device and configured to broadcast Basic Safety Messages. During the demonstration, an Apple iPad with 4G LTE connectivity was used to display the USDOT Southeast Michigan Architecture Visualizer tool. This tool visually depicts data that is deposited by various connected vehicle applications into the USDOT Southeast Michigan Data Warehouse.

During the demonstration, the visualizer tool displayed an interactive map of Detroit's DSRC enabled corridor. At each DSRC enabled intersection on the map, the current state of the traffic signals, along with near-real-time "breadcrumbs" of the test vehicle were depicted. These color coded breadcrumbs indicated the current speed of the vehicle. The participants were able to witness the creation of the breadcrumbs through the corridor, along with the corresponding change in state of traffic signals as they were navigated.¹⁸ The demonstration consisted of one single trip through the connected corridor "loop," lasting about 20 minutes.

The six (6) participants were recruited as volunteers from the Southeast Michigan Council of Governments (SEMCOG) main office.¹⁹ The volunteers are actively engaged with transportation issues to various levels through their employment at SEMCOG. Further, a few of the volunteers casually researched connected vehicles upon volunteering for the demonstration. These factors suggest that the results of the exit-interviews should not be considered as representative of the general public. The exit-interviews are nonetheless valuable as they provide a sample of responses by relatively well-informed professionals.

3.1 CONCEPTION OF THE TERM, "CONNECTED VEHICLE"

Subjects were asked to reflect on their conception of the term, "connected vehicle," in a general sense. Three of the six subjects were generally familiar

¹⁸ While the Detroit DSRC Corridor is set-up for Signal Phasing and Timing (SPaT), the SPaT application was not working correctly on the day of the test, possibly due to non-coordination between Detroit DOT and the Detroit test-bed management team.

¹⁹ Volunteers were compensated \$30 each for their time commitment.

with the USDOT connected vehicle program and were able to describe the system rather accurately:

“I know that vehicles will be able to talk to each other and in the sense of knowing their positions, so there’s a lot of safety implications to that like whether a vehicle stops abruptly or something’s happening ahead of you that your vehicle gets notified.”

One subject responded that the term connected vehicle suggests to them more commercial applications, such as GPS navigation or internet connectivity. The three aforementioned subjects with accurate description of the USDOT connected vehicle program also admitted that this would have been their conception until recently, when they had learned about the USDOT connected vehicle program.

The final two subjects described a response to the term connected vehicles that was more reflective of automated vehicle technology:

“...driverless cars, or cars that aren’t going to hit each other; ... they’re all going to be controlled by someone else.”

3.2 FAMILIARITY WITH USDOT CONNECTED VEHICLE PROGRAM

Four of the six subjects were familiar with the USDOT Connected Vehicle Program previous to the demonstration. Two of these were able to describe the basic approach of the program:

“I know that there are a lot of test beds that are happening, you know testing a variety of communication technologies and really offering up platforms for third parties to come out and test various applications. I don’t know if there are certain aspects that are U.S. DOT or the whole thing is DOT but I know of various applications that are happening and such.”

“It’s there to enable manufacturers to innovate in this space, to be able to get everybody talking the same language so that they’re able to then have multiple vehicles from many different places that are able to give out safety information and other aspects that would allow you to know more about the road system, the state of it, where you’re going and so forth.”

3.3 INITIAL THOUGHTS OF V2I DEMONSTRATION

The exit-interview opened by providing the subjects an opportunity to reflect their initial, un-guided impression of the demonstration they had just experienced. All six subjects described the experience as “interesting,” or similarly. Yet all six eschewed a measured disappointment in the experience; they generally expected to observe a more-developed application. The initial plans for the demonstration were, in fact, to show the subjects a functional SPaT application. Unfortunately, SPaT was not functioning within the test bed on that day. What the subjects witnessed was a development application that showed only the current state of an upcoming signal, and the location and speed of the test vehicle. Other than the live traffic-signal data, the application appears like a basic GPS tracking app. It is thus, perhaps, expected that the subjects were not enthusiastically impressed:

“I’ve seen other demonstrations and that’s why I was kind of expecting more I guess.”

“I don’t know if it would inform me a lot from what I saw today and cause me to do something differently as far as routes but I think it appeared like the layers to create some potential for other things. ... I’m looking forward and thinking what might be the potential of this.”

“We heard so much about these connected cars that here we were just seeing the lights, we were wondering if there was more to see and so it seemed like it wasn’t as connected as some of the media tells us.”

“I hadn’t thought too much—and this is what we talked about a lot [with the Leidos Technician]—what needs to happen with the infrastructure on the roads. When you hear about vehicle connectivity, ... it’s two cars talking to one another and preventing an accident or something like that. [But] it seems like hasn’t even been fully determined what we can do if everything’s connected. I came out of it, probably, with more questions than answers.”

One subject who subsequently demonstrated a fair amount of understanding of the USDOT connected vehicle program reported a new appreciation for the complexity of the system, and difficulty in successfully deploying even simple applications:

“I [found noteworthy] the amount of language and baseline infrastructure for the IT portion of it that needs to be built up in order for any of this to take place... The more we talked [to the Leidos technician] the more detail was gotten into about how many times the ... security certificates need to change ... and the deliberate way that all the manufacturers need to be pooling together to have one universal way of approaching this. It’s a large undertaking to even get to the simple step of showing when a light is going to change.”

3.4 INTEREST IN SIGNAL PHASE AND TIMING APPLICATIONS

In the spirit of the initial concept of the demonstration—which would have showed subjects a SPaT application, signal phase and timing was conceptually described to the subjects, and they were subsequently asked their opinion on the potential application. Subjects were generally enthusiastic:

“I would love it. I’m always looking at the ‘ped-heads’ to see how much time I have before a change of signal, or looking for any sort of other context clues. I don’t want to accelerate or decelerate faster than I need to in order to get through it.”

Though generally positive, most subjects qualified their opinion of SPaT with doubts about real-world suitability:

“Traffic on Gratiot Avenue here in Detroit, speed limit is posted at 30 or 35 miles per hour, most people probably drive 40 or 50 miles an hour on there, but I don’t know what the signals are timed along there posted what speed. If I’m an engineer doing the signal timing and I post it for 45, but the posted speed limit is 30, then your application is promoting people to drive faster. Those would be the kind of concerns that I would have.”

“I’m hesitant to be overly optimistic about it because that presumes that there are not going to be any obstacles in my way ... and all the other variables that can happen between me and reaching that signal regardless of my knowledge that I have to go 25. Is that going to lead me or somebody else to make an otherwise unsafe driving decision?”

“I grew up in Boston... I don’t know how familiar you are with Boston drivers, but that would be terrifying, having that.”

3.5 INTEREST IN V2V FOR SAFETY APPLICATIONS

Subjects were told that the primary impetus for the USDOT connected vehicle program was not V2I applications, but V2V for safety. Subjects were asked how interested they would be in having V2V safety features on their own personal vehicle. All six subjects were highly positive about the prospect:

“I could see that not even on a roadway, but even entering a roadway a lot of times it’s hard to tell if there’s a vehicle in a certain area. It seems that could be helpful on so many levels.”

“I would be interested for sure. One time I’ve seen somebody pull out of an intersection when they shouldn’t have and they got T-boned. If there was the ability to avoid anything like that, that would be awesome.”

“Safety features that are reliable, that lower the chance that you get wrecked, that’s nice. I guess cost is the [variable] that I’m not sure.”

3.6 REACTION TO POTENTIAL USDOT CONNECTED VEHICLE MANDATE

Subjects were told that the USDOT is considering enabling broad-scale deployment of connected vehicle technology by adopting a mandate for V2V connectivity. Subjects were asked to reflect on a potential mandate—not only as individuals, but also with regard to their position within SEMCOG. All six respondents were generally positive about a mandate scenario. Three of the subjects qualified this opinion with the concern of raising the cost of a vehicle. Two subjects noted that even with a mandate, the turnover rate of the vehicle fleet implies an extended time to universal adoption.

3.7 MOST INTERESTING APPLICATIONS

After discussing SPaT and V2V-for-safety, subjects were asked what aspects of connected vehicle technology they feel is the most interesting, or has the most potential to positively influence the transportation system. None of the subjects described a distinct ‘application’ (as the term is used in the USDOT Connected Vehicle Program), but all expounded on concepts related to safety and/or mobility in very general terms:

“I’m interested in... is there a way that this technology can be used to maximize throughput system; minimize congestion so that you don’t have to build more, get the most out of the system we have?”

“I would say that I’m interested the most in safety. In terms of throughput, I’m interested in that as well, especially as regards to transit vehicles.”

3.8 EXPECTATIONS FOR THE FUTURE

Subjects were asked to describe their expectations about the long-term future of transportation and the “driving experience.” The time horizon suggested was “twenty to thirty years” in the future. Subjects responded with appropriate uncertainty while discussing familiar themes of future transportation including self-driving vehicles, mobility-as-a-service, and customized travel information.

“I have a sense that maybe there will be more of the smart car type stuff where I don’t need to own a car but maybe I can just dial up the smart vehicle will come up and be available to me, just like bike share programs.”

“I can see all kinds of ways that you might start getting more real-time information beyond what we already get in a more easily accessible focus kind of way.”

“Right now when the message boards on the freeways go up and they either give you the travel time or they may say ‘expect delays’, they don’t give you a lot of information there. Maybe you’ll get more information out of this where if something is going to delay me probably 30 minutes or maybe 20 minutes.”

“Vehicles becoming much more automated in the way that you don’t have to be as alert to every single circumstance on the road. Will that get to the point where it’s 100 percent; where no one’s actually driving a vehicle? I don’t know, maybe in the next 30 years.”

“Going away from the ownership model is definitely something that we’re moving towards.”

“I would expect car-like vehicles to still be around. The roads aren’t going to change as much as the vehicles themselves are going to change.”

“The safety aspects are just a huge selling point [of automated vehicle technology] ... The concerns about giving up control—when demonstrated that automated systems can do it safer than human systems, we’ll all be much more comfortable with vehicles doing more for us.”

“I think there is going to be a fair amount of stuff coming to people—not people going to stuff. Like retail, delivery, health care...”

“It’s my hope that more people as they need to get around rely on mass transit to do so, and that urban transit systems will improve to meet that demand. But I don’t know if that’s a realistic thing to expect.”

3.9 ROLE FOR MICHIGAN

Subjects were asked—from the perspective of “residents and taxpayers in the State of Michigan”—if they believed that state government should be responding to advancements in connected vehicle technology, and how so. A general theme in responses was that the state has an important role to play in promoting advanced automotive technologies for safety, mobility, and economic development. As employees of SEMCOG, the respondents were particularly capable of discussing such issues:

“It would really be nice to see the State of Michigan be a pioneer state... [This is] the birthplace of big mass auto. It doesn’t mean that you need to cling to that, but it is an important part of everyone’s everyday life.”

“If there’s efficiency and safety, if those are the things they are pushing, then yes, I think it’s a good thing.”

“I think it would be money well spent from safety standpoints. I think it’s definitely been proven that this type of transportation infrastructure is going to be invested in heavily, why not be a little ahead?”

“As far as economic development goes, this state should be building off its economic base by innovating in this area as much as possible, with as many of its resources that it can muster with its connection to the auto companies and the OEMs.”

“If it’s a public benefit... Let’s just make better use of our existing roadways...”

“I think it could be a big driver of our economy... Our state can’t afford to lose its role in mobility and transportation. The state has a real interest in making sure that those companies can test and develop and deploy it with the technology and talent here.”

“If the State sees it as a real safety issue and something that could solve that issue, I think it’s important just based on that.”

“From an economic standpoint, if we want to remain the automotive capital, then this is an important part of that industry and we need to be right up there with it.”

“This whole concept of capturing this industry and keeping it here is big on the minds of those that are involved in economic development, whether it be the counties or the county executives; they’re hearing all of this stuff out there and see it as an opportunity. I think that we want to be able to showcase this and keep that here.”

3.10 CONCERNS

Subjects were not explicitly asked about concerns regarding the technology. But in the course of the exit interview, there were some recurrent themes related to general concerns that were brought up by multiple subjects, as discussed below.

IMMATURE STATE OF TECHNOLOGY

One observation made by all six subjects is that the technology demonstrated to them did not appear mature or consumer-ready. This is likely an understandable reaction; the SPaT feature of the Detroit test-bed was not available for demonstration. Subjects were only able to see the USDOT Southeast Michigan Architecture Visualizer tool—a developer-focused platform which showed only the location of the test vehicle and the current state of the upcoming signal.

DATA PRIVACY

Another concern was related to data privacy. Two separate subjects referenced “Big Brother”—the fictional surveillance state in George Orwell’s novel, *Nineteen Eighty-four*. Subjects were not particularly concerned for their *own* privacy, but anticipated that such issues would make broad adoption of connected vehicle technology politically difficult:

COST

Most subjects mentioned a concern about the cost of connected vehicle technology. This was frequently brought-up when subjects discussed the possibility of a USDOT mandate for connectivity. Most subjects were concerned about adding cost to the vehicle itself. If V2V capability adds too much cost, it will place a financial burden on many people and possibly delay the adoption of V2X and related benefits. One subject mentioned the cost of deploying and operating a complex connected vehicle network.

REAL-WORLD APPLICABILITY

Instead of demonstrating SPaT to subjects, the SPaT application was described to them. Subjects were then asked how interested they would be in such an application. As previously discussed, interest was high. But most subjects also expressed a concern that SPaT wouldn't, or couldn't, be designed in such a way that would result in the intended benefits. They predicted that people would use SPaT information—not to improve traffic flow and efficiency—but to 'game the system,' (e.g., to speed up to make sure you make the next light, regardless of SPaT advisory speed). In fact, a couple subjects admitted that is why they were personally interested in the application.

One subject who showed familiarity of traffic crash data questioned the impact of V2V-for-safety applications. The subject noted that the majority of severe crashes in the United States are single vehicle crashes. The subject questioned the impact that V2X could have on these crashes.

4 WEB SURVEY

CAR designed a web-based survey administered through Survey Monkey and aiming to shed light on the perceptions that the U.S. population has of connected and automated vehicle technology.

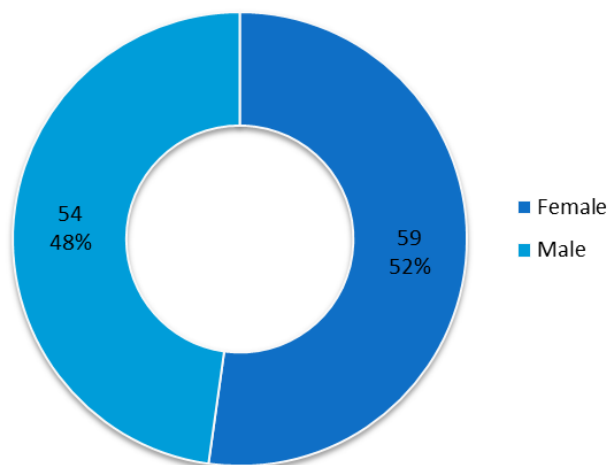
The 114 participants were asked about their impressions, experience, interest, and confidence in CAV technology, as well as about the benefits and concerns with CAV.

4.1 OVERALL DEMOGRAPHICS OF THE PARTICIPANTS

GENDER

The gender ratio was relatively evenly, with forty-eight percent of respondents being men and fifty-two percent women (see Figure 10).

FIGURE 10: GENDER OF RESPONDENTS

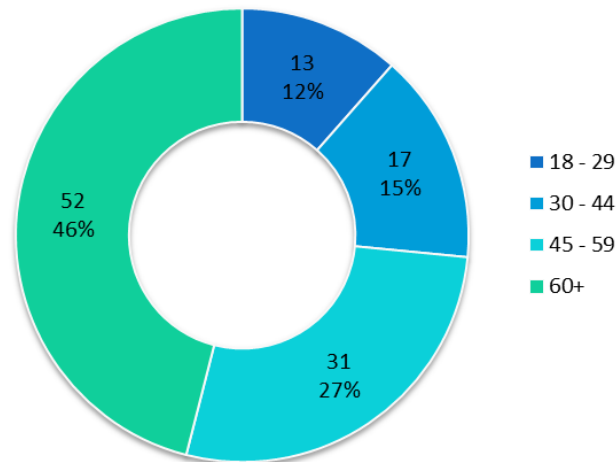


count and percent; n=113

AGE

Respondents in this survey skewed older, with age sixty and older making up almost half of the total respondents (46 percent), whereas this age group represents only 18.4 percent of the entire U.S. population²⁰. When including the 45-59 age range, nearly three-quarters of respondents were 45 and older. No respondents were younger than 18 years (see Figure 11).

FIGURE 11: AGE OF RESPONDENTS



count and percent; n=113

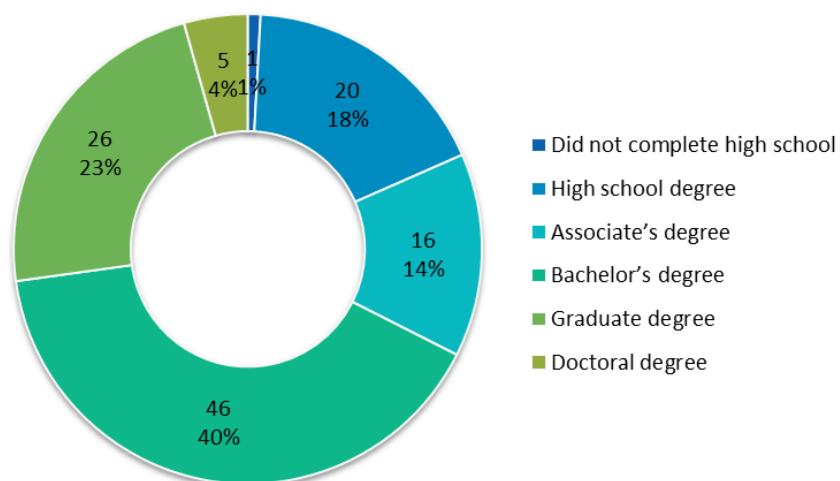
EDUCATIONAL ATTAINMENT

The majority of respondents had a Bachelor's degree or beyond, totaling 67 percent. For comparison, 27.9 percent of the U.S. population holds a Bachelor's degree or more²¹, which makes the average participant in the CAR survey more educated than the national average (see Figure 12).

²⁰ Source: 2010 U.S. Census: <http://www.census.gov/prod/cen2010/briefs/c2010br-03.pdf>

²¹ Source: Educational Attainment in the United States: 2009, <http://www.census.gov/prod/2012pubs/p20-566.pdf>

FIGURE 12: EDUCATIONAL ATTAINMENT



count and percent; n=114

HOUSEHOLD INCOME

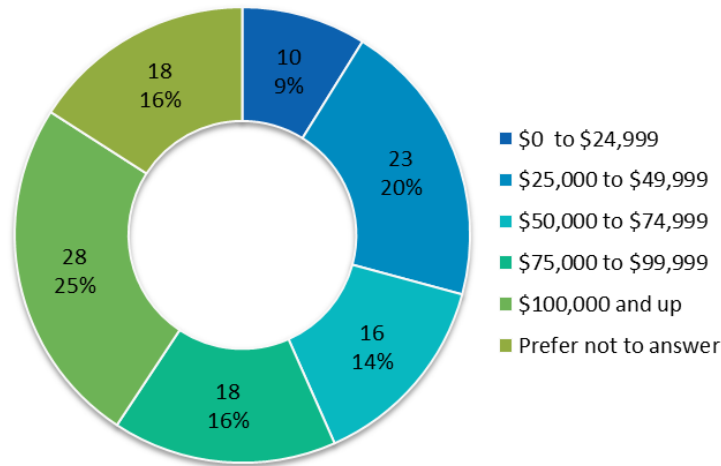
While 16 percent of respondents chose not to answer, a quarter of respondent households earned more than \$100,000 per year (see Figure 13). For comparison, only 19.5 percent of all U.S. households earned more than \$100,000 per year²², which makes the CAR sample wealthier than the U.S. population.

Over 40 percent of CAR respondents earned a household income of \$75,000 or more. 34 percent of respondents earned between \$25,000 and \$74,000, and nine percent were in the lowest income level category of \$0 to \$24,999. At the national level, also nine percent of the population earned less than \$25,000²³.

²² Source: Elwell, C.K. "The Distribution of Household Income and the Middle Class", March 10, 2014. <https://fas.org/sgp/crs/misc/RS20811.pdf>

²³ Source: Elwell, C.K. "The Distribution of Household Income and the Middle Class", March 10, 2014. <https://fas.org/sgp/crs/misc/RS20811.pdf>

FIGURE 13: HOUSEHOLD INCOME

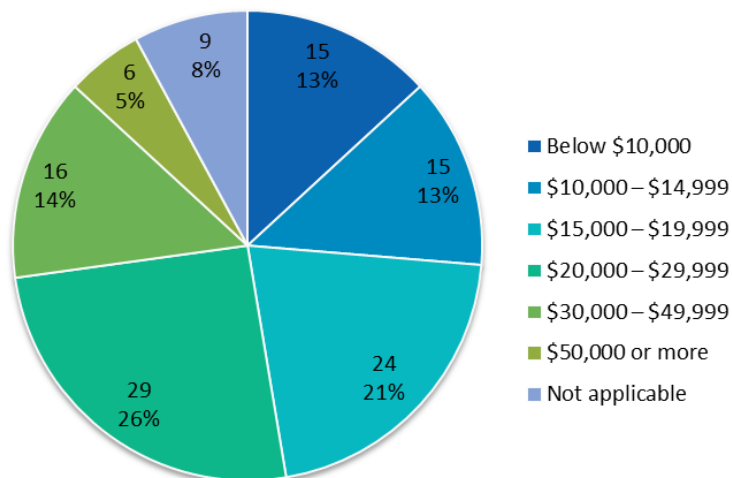


count and percent; n=113

AMOUNT PAID FOR VEHICLE

Respondents were asked how much they paid for their most recently purchased new or used car. More than a quarter of all participants paid between \$20,000 - \$29,000. When combined with the higher cost categories, 44 percent of respondents paid \$20,000 or more for their vehicle, indicating a relatively even mix of respondents purchasing economy vehicles and those purchasing more expensive options (see Figure 14).

FIGURE 14: AMOUNT PAID FOR VEHICLE

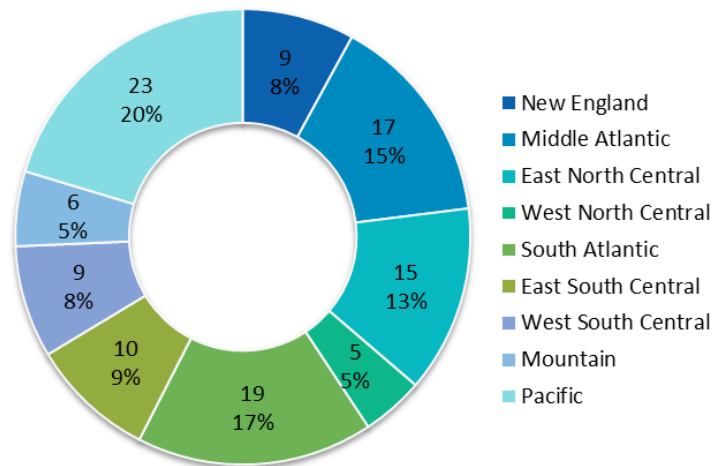


count and percent; n=114

GEOGRAPHIC LOCATION

All United States Census regions were represented in the survey sample (see Figure 15). The Pacific region, including Alaska, California, Hawaii, Oregon and Washington, was the largest at 20 percent, and West North Central, including Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota, was the least represented at four percent. Michigan is part of the East North Central region where 13 percent of respondents live.

FIGURE 15: GEOGRAPHIC DISTRIBUTION OF RESPONDENTS

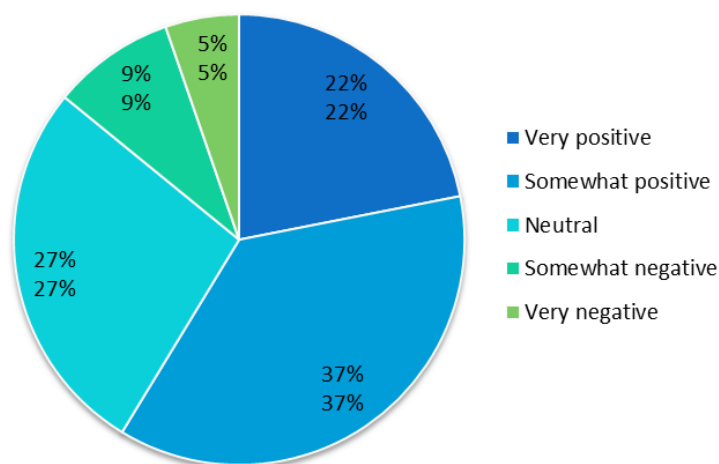


count and percent; n=113

4.2 OVERALL IMPRESSIONS OF CAV

Over half of respondents (59 percent) had a somewhat or very positive view of connected and automated vehicles, and only 14 percent had a somewhat or very negative view of the technology. Thus, a solid majority of respondents have generally positive impressions of the technology (see Figure 16).

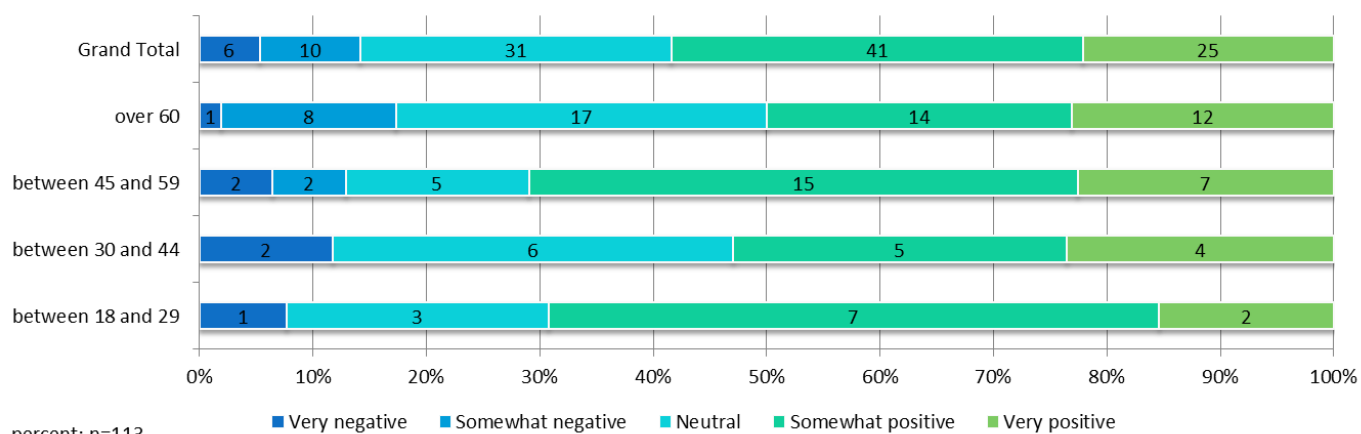
FIGURE 16: GENERAL IMPRESSIONS OF CONNECTED AND AUTOMATED VEHICLES



count and percent; n=114

There does not appear to be a significant trend when the answers are broken down by age. However, interestingly, the two age groups that were most likely to have a somewhat or very positive impression of the technology were the 18-29 (9 of the 13 participants, or 69.2 percent of this age group) and the 45-59 (22 of the 31 participants, or 71 percent in this age category) groups (see Figure 17).

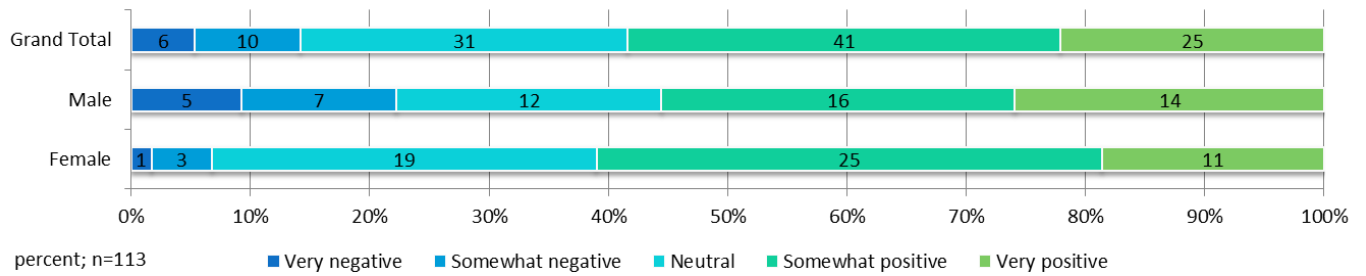
FIGURE 17: GENERAL IMPRESSIONS OF CAV, BY AGE



percent; n=113

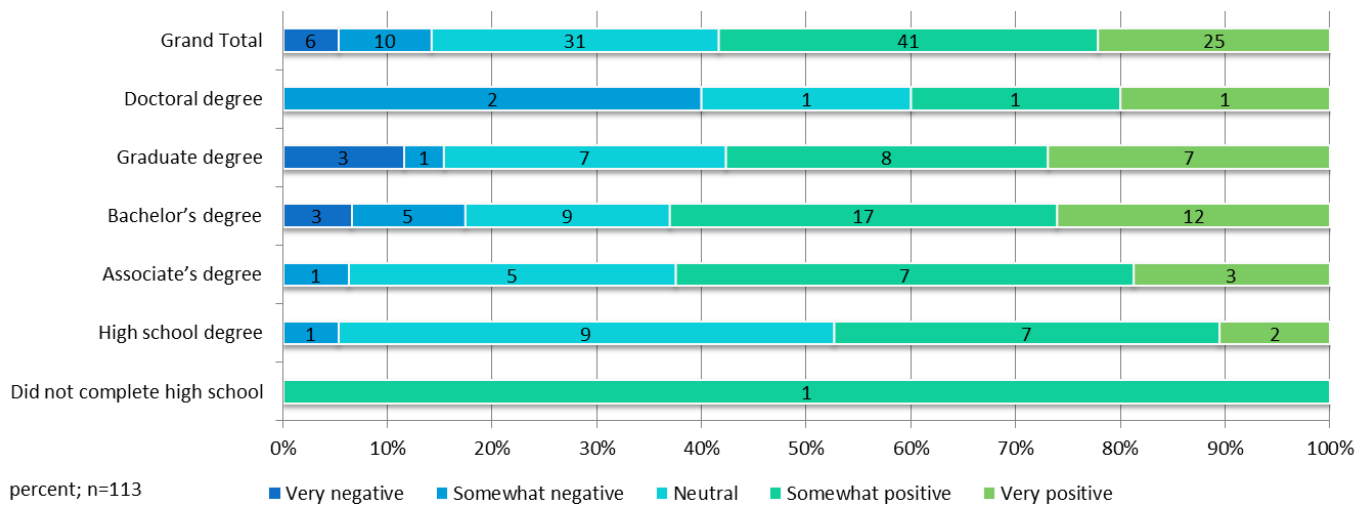
There are differences in the participants' responses when broken down by gender. Precisely, men were three times more likely to have a very negative or somewhat negative impression of CAV; 12 of the 54 male participants or 22.2 percent had this view, whereas only four of the 59 female respondents or 6.8 percent had a very negative or somewhat negative impression (see Figure 18).

FIGURE 18: GENERAL IMPRESSIONS OF CAV BY GENDER



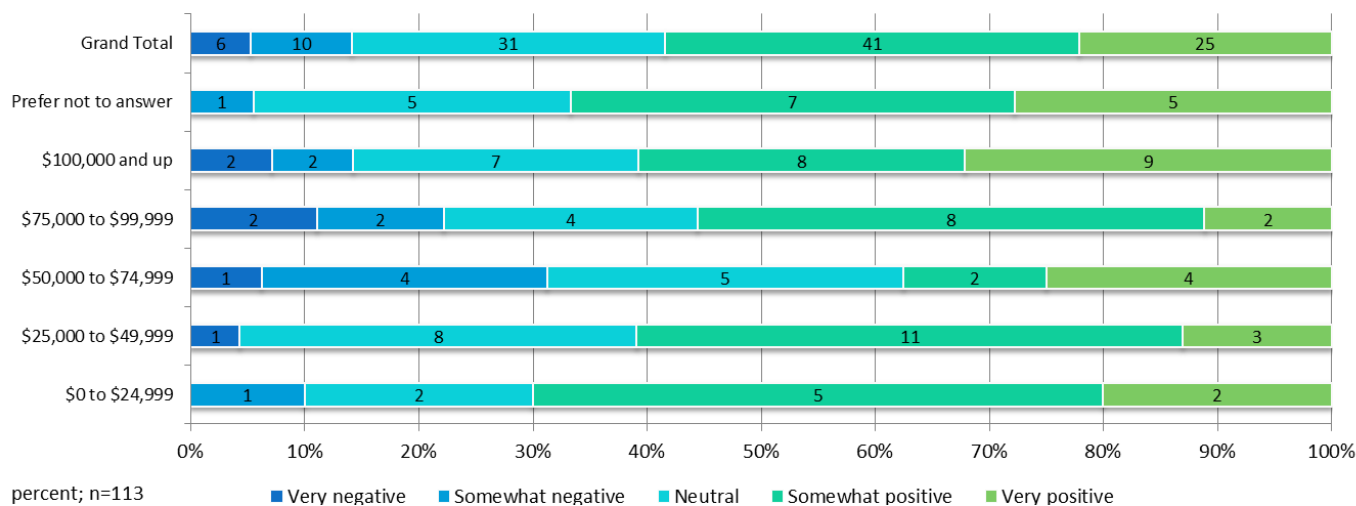
The analysis by level of education reveals a partial trend. The more educated the participants were, the more likely they were to have a very or somewhat negative impression of CAV technology (see Figure 19).

FIGURE 19: GENERAL IMPRESSIONS OF CAV, BY EDUCATIONAL ATTAINMENT



Similarly, the survey results indicate that the impressions of CAV technology are correlated with household income. The lower the household income of the participants, the more negative the impression of CAV (see Figure 20).

FIGURE 20: GENERAL IMPRESSIONS OF CAV, BY HOUSEHOLD INCOME



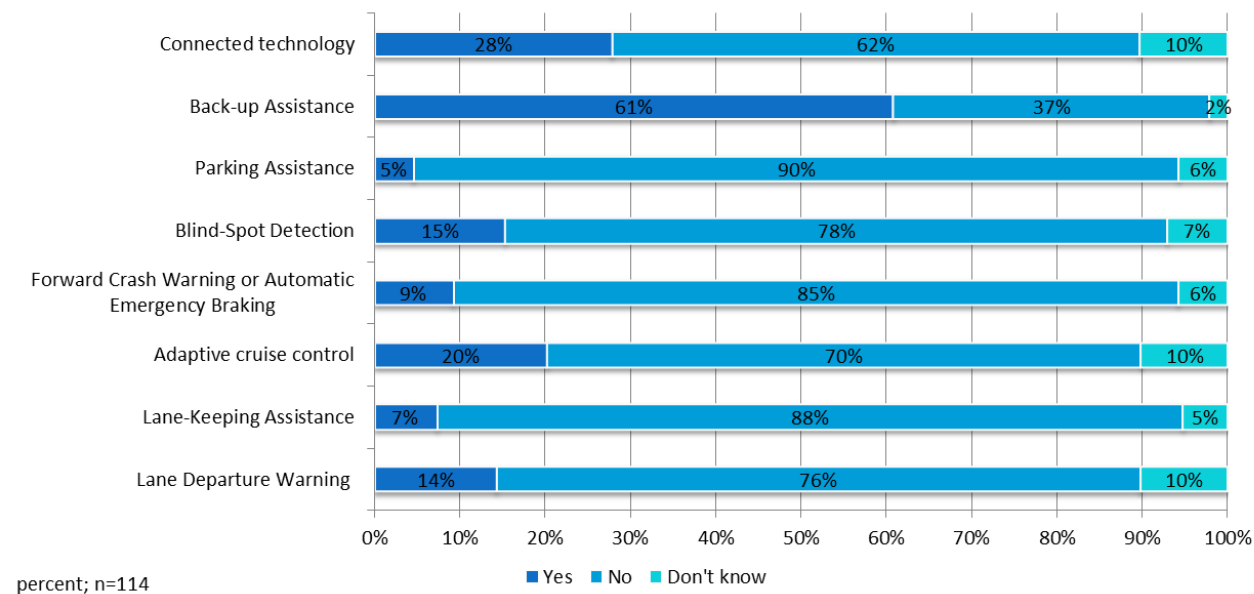
4.3 EXPERIENCE WITH CAV TECHNOLOGY

Respondents were asked if they had any experience driving a vehicle with a variety of connected and automated features (see Figure 21).

The only technology for which a majority of respondents said they had experience was Back-up Assistance (61 percent).

The three least familiar applications were Parking Assistance (five percent), Lane-Keeping Assistance (seven percent) and Forward Crash Warning/Automatic Emergency Braking (nine percent).

FIGURE 21: EXPERIENCE DRIVING VEHICLE WITH VARIOUS CAV APPLICATIONS



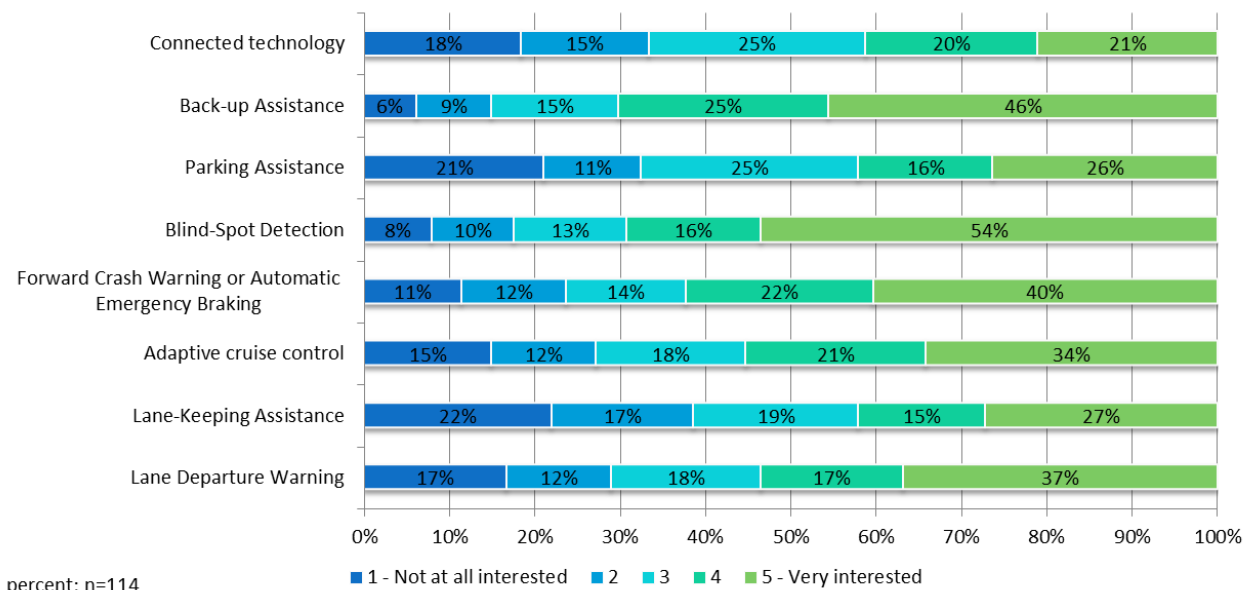
4.4 INTEREST IN SPECIFIC CAV APPLICATIONS

Overall, participants were mostly interested in using CAV applications.

The most appealing CAV application was Blind-Spot Detection, with 54 percent of the respondents indicating they were very interested in using that technology. Back-up Assistance was the second most popular technology, with 46 percent respondents stating they were very interested in using it.

The least popular application was Lane-Keeping Assistance, with 22 percent of respondents stating they were not at all interested in the technology. Parking Assistance and Connected Technology also raised relatively little interest, with one in five participants stating they were not at all interested and about the same number replying that they were very interested. For more details, see Figure 22.

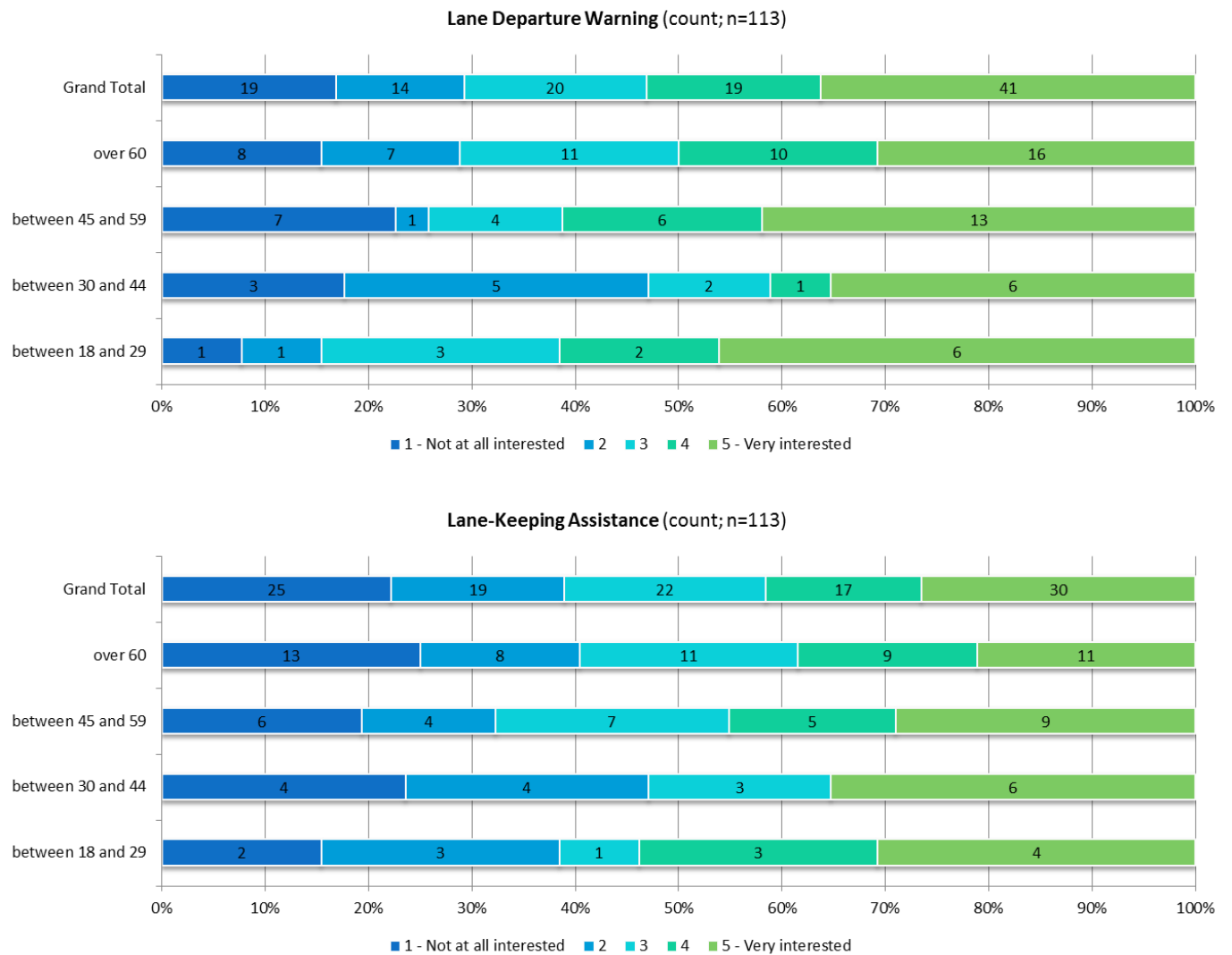
FIGURE 22: INTEREST IN SPECIFIC CAV APPLICATIONS



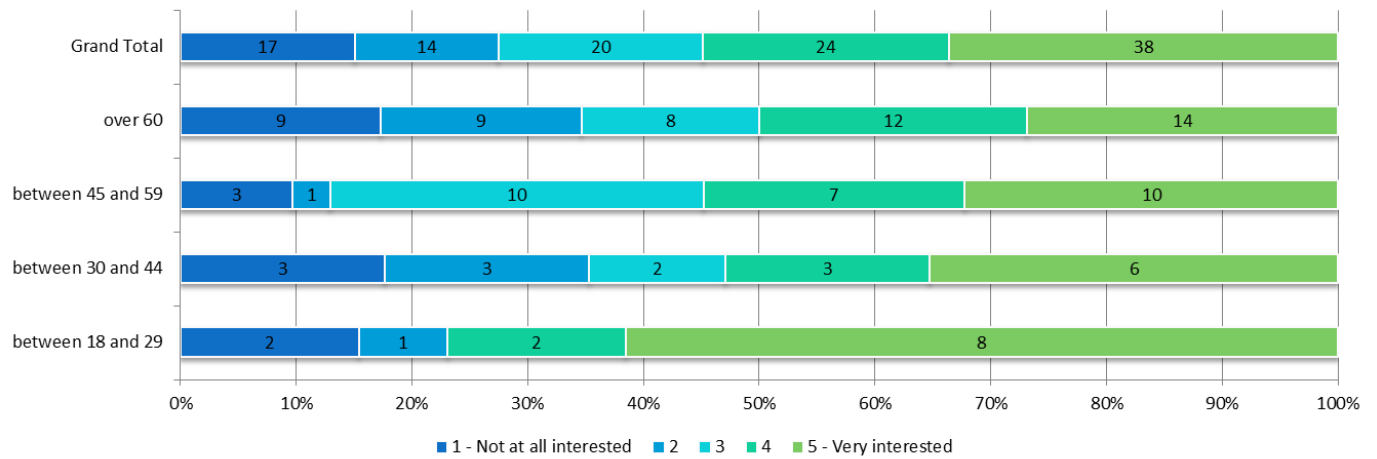
When analyzed by age, the replies to this question reveal some interesting differences (see Figure 23). Overall, participants between 30 and 44 years were the least interested in the CAV applications. Lane Departure Warning, Forward Crash Warning, and Blind-Spot Detection were particularly interesting for the participants in the age ranges 18-29 and 45-59. In addition, participants between 18 and 29 years were the most likely group to be interested in Lane Keeping Assistance, Adaptive Cruise Control, and Parking Assistance. Back-up Assistance was deemed interesting to the greatest extent

by participants between 45 and 59 years. Finally, the 30-44 age category was the group most interested in Connected Technology.

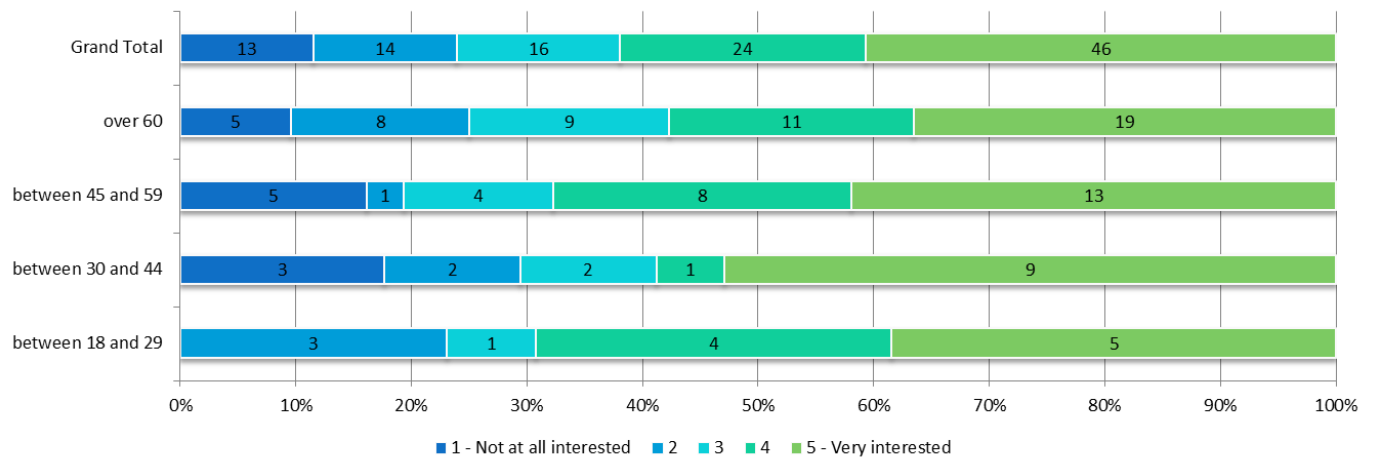
FIGURE 23: INTEREST IN SPECIFIC CAV APPLICATIONS, BY AGE



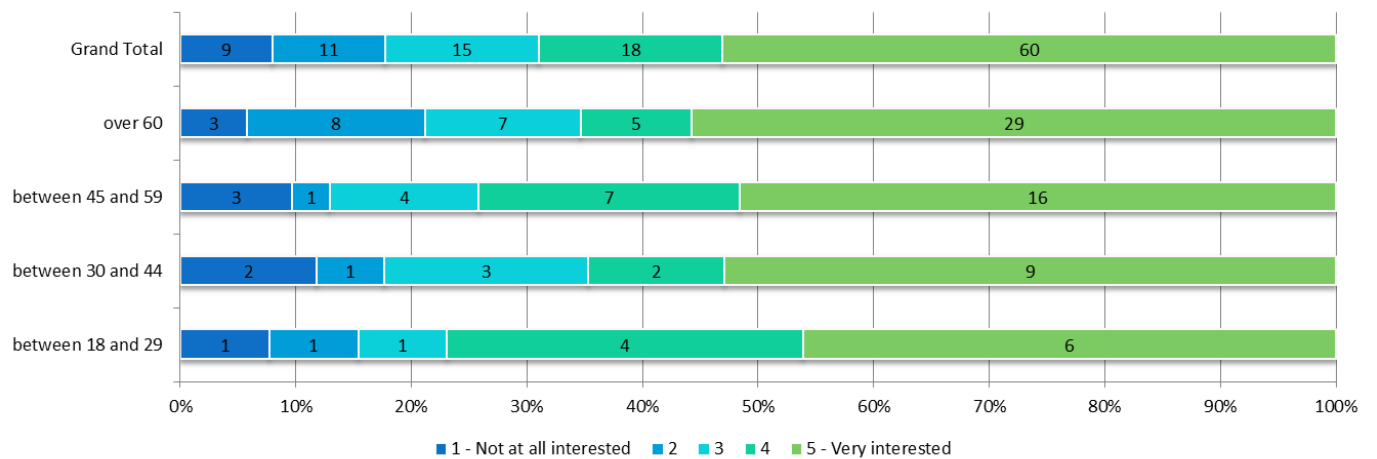
Adaptive Cruise Control (count; n=113)



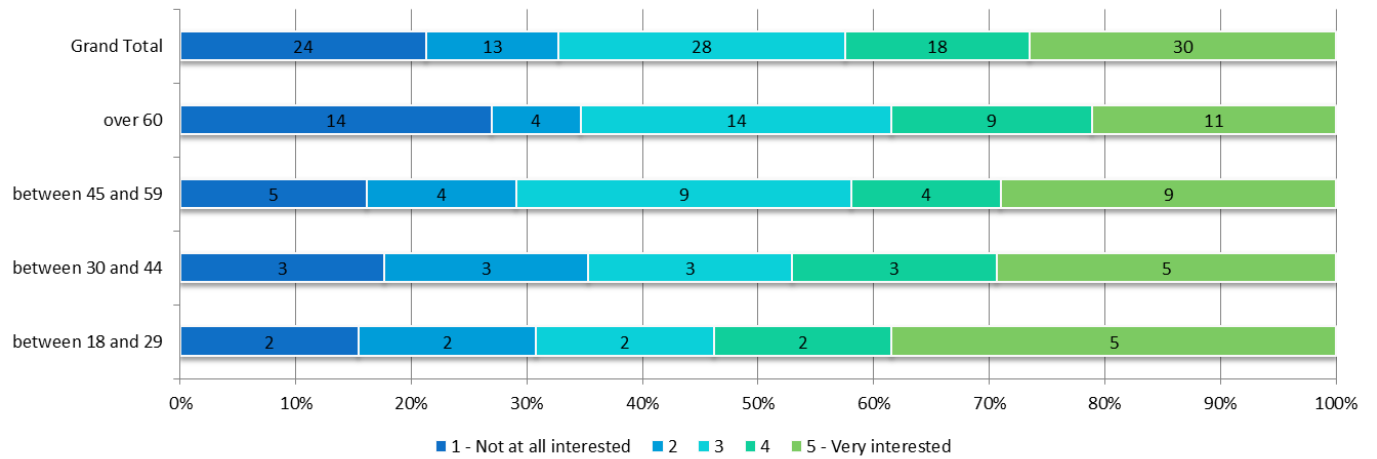
Forward Crash Warning or Automatic Emergency Braking (count; n=113)



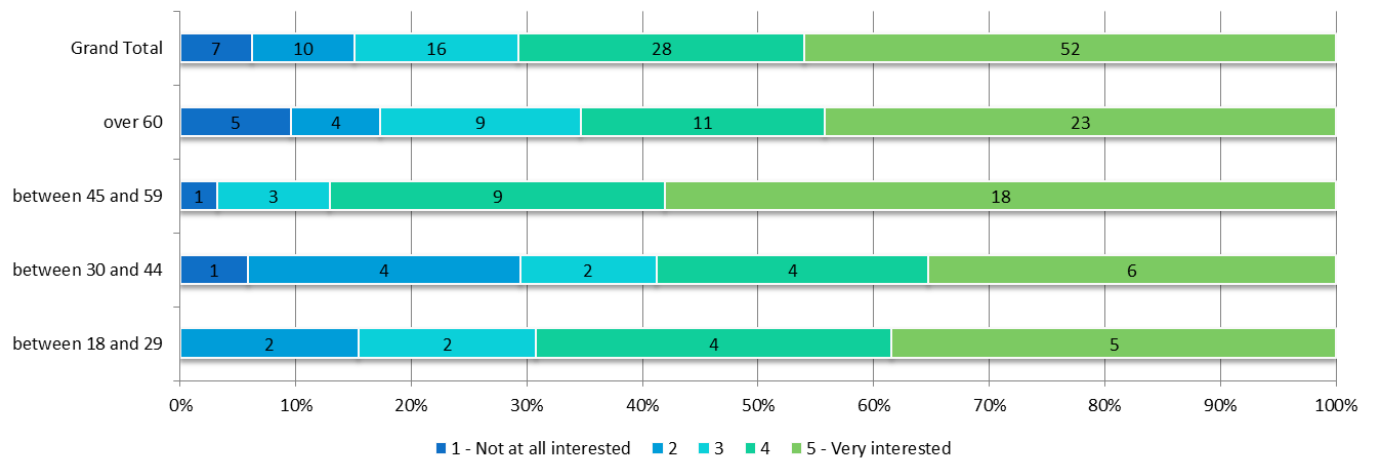
Blind-Spot Detection (count; n=113)



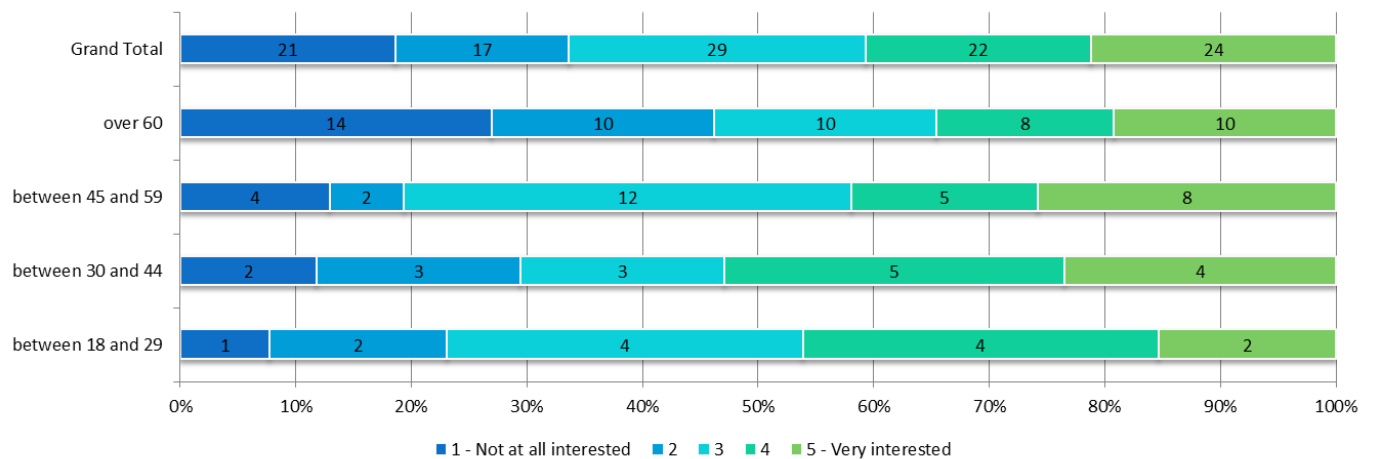
Parking Assistance (count; n=113)



Back-up Assistance (count; n=113)



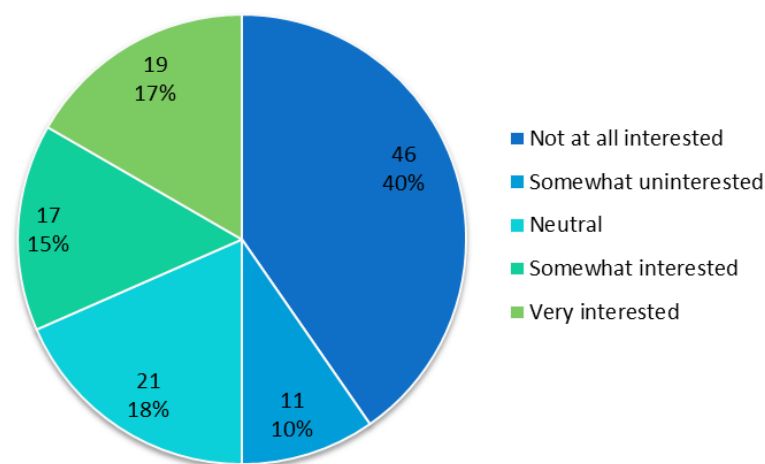
Connected technology (count; n=113)



4.5 INTEREST IN OWNING OR LEASING AN AUTONOMOUS VEHICLE

Despite having generally positive impressions of CAV technology, half of respondents showed little-to-no interest in owning or leasing a fully autonomous vehicle (see Figure 24). Only a third of the participants were very or at least somewhat interested in self-driving vehicles. This suggests respondents were more comfortable with partial autonomy and the connected side of technology, than with the fully-automated.

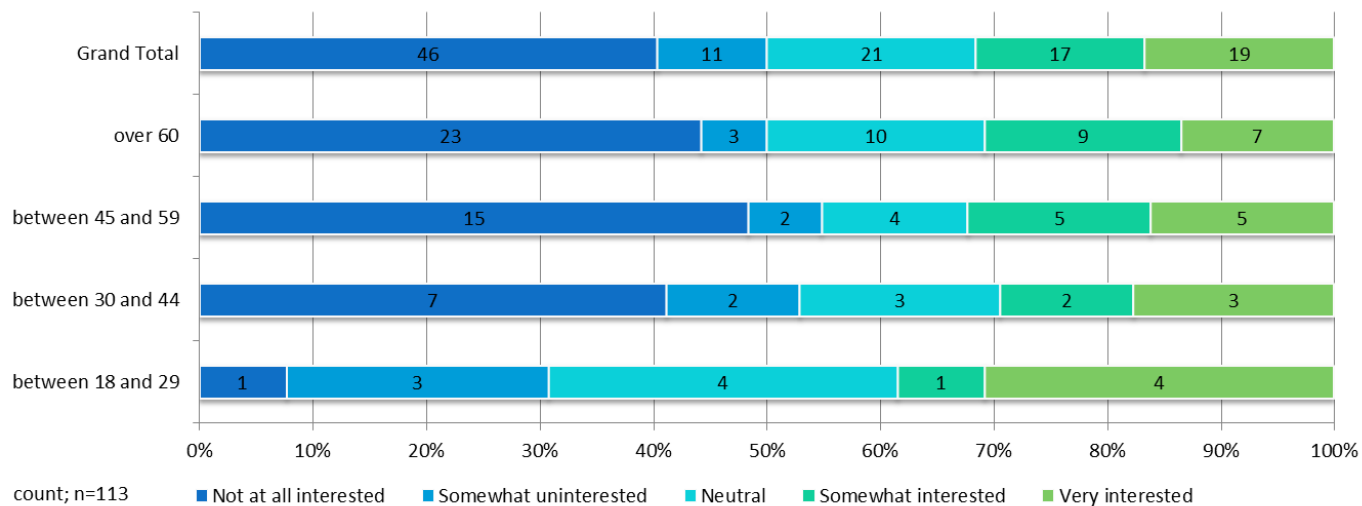
FIGURE 24: INTEREST IN OWNING OR LEASING AN AUTONOMOUS VEHICLE



count and percent; n=114

When comparing responses by age range, a key takeaway is that participants in the 18-29 years category represented the group most interested in autonomous vehicles (see Figure 25). Precisely, 30 percent of them were very interested in autonomous vehicles.

FIGURE 25: INTEREST IN OWNING OR LEASING AN AUTONOMOUS VEHICLE, BY AGE



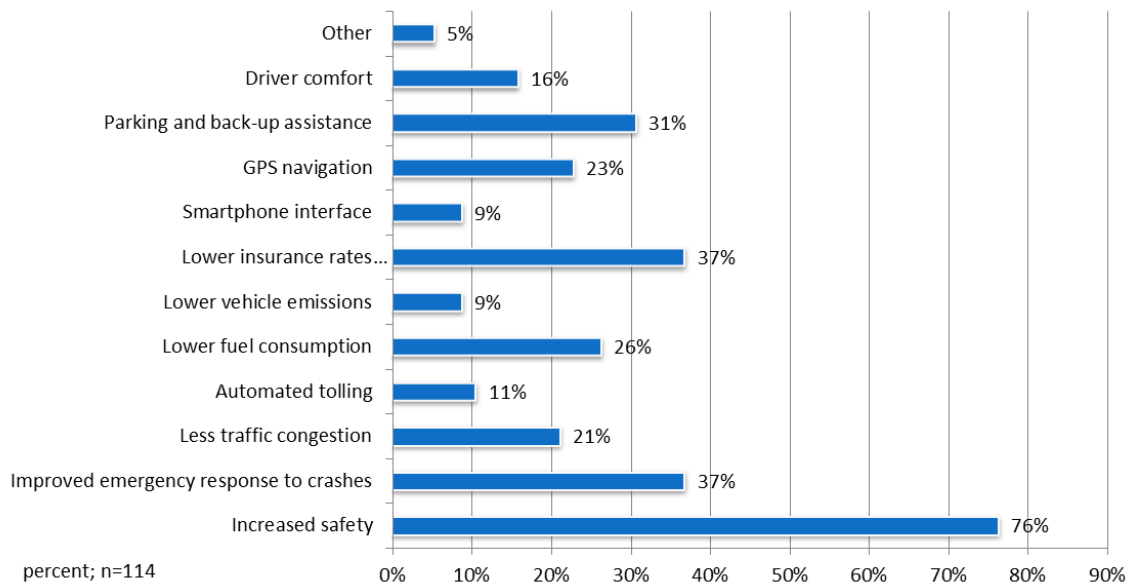
4.6 PERCEIVED CAV BENEFITS

Respondents were asked to list the top three benefits they believe CAV vehicles will provide. The most-selected option by far was ‘increased safety’, at 76 percent. Because this category is the broadest of those listed, it is logical that it is the most commonly selected choice (see Figure 26).

The next two benefits that received the highest ratings were ‘improved emergency response to crashes’ and ‘lower insurance rates’ at 37 percent each. It is interesting that insurance rates were commonly thought of as a benefit, since that represents a direct financial benefit to CAV consumers possibly as counter-balancing an increase in vehicle cost for the technology.

A notable fourth benefit is ‘parking and back-up assistance’ at 31 percent. This relates to perceived driver convenience from CAV technology.

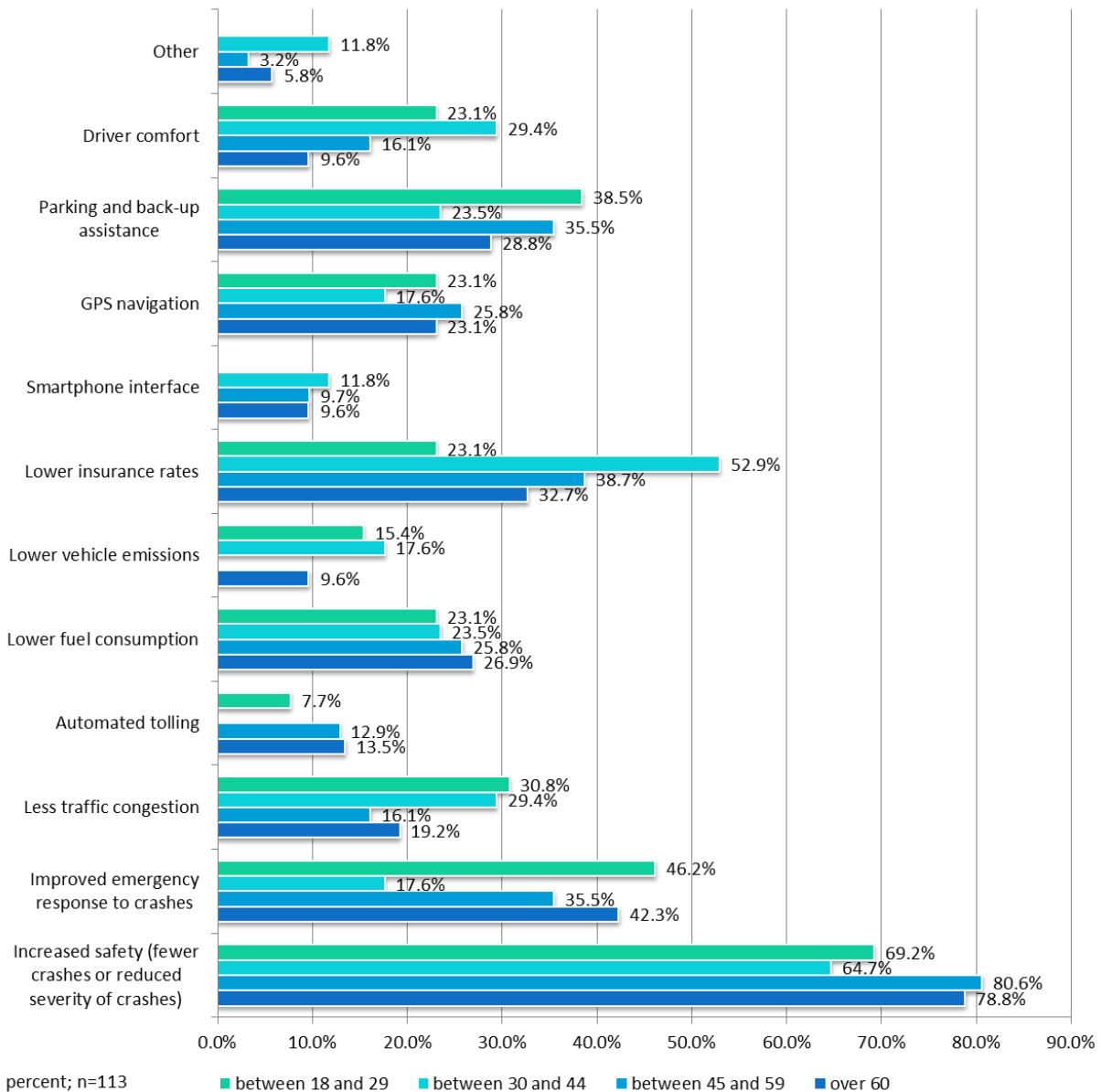
FIGURE 26: PERCEIVED BENEFITS OF CAV TECHNOLOGY



When the replies are analyzed by age, the results indicate that some perceived benefits were correlated with age, whereas others were not.

Participants under 45 years were most likely to mention lower vehicle emissions and less traffic congestion. Respondents aged 18 to 29 were the group that selected the ‘parking / back-up assistance’ and ‘improved emergency response to crashes’ options the most. The 30-44 age group believed the strongest that one of the top CAV benefits is represented by lower insurance rates. Finally, participants over 45 years were more convinced than their younger counterparts that CAV would increase vehicle safety. For more details, see Figure 27.

FIGURE 27: PERCEIVED BENEFITS OF CAV TECHNOLOGY, BY AGE

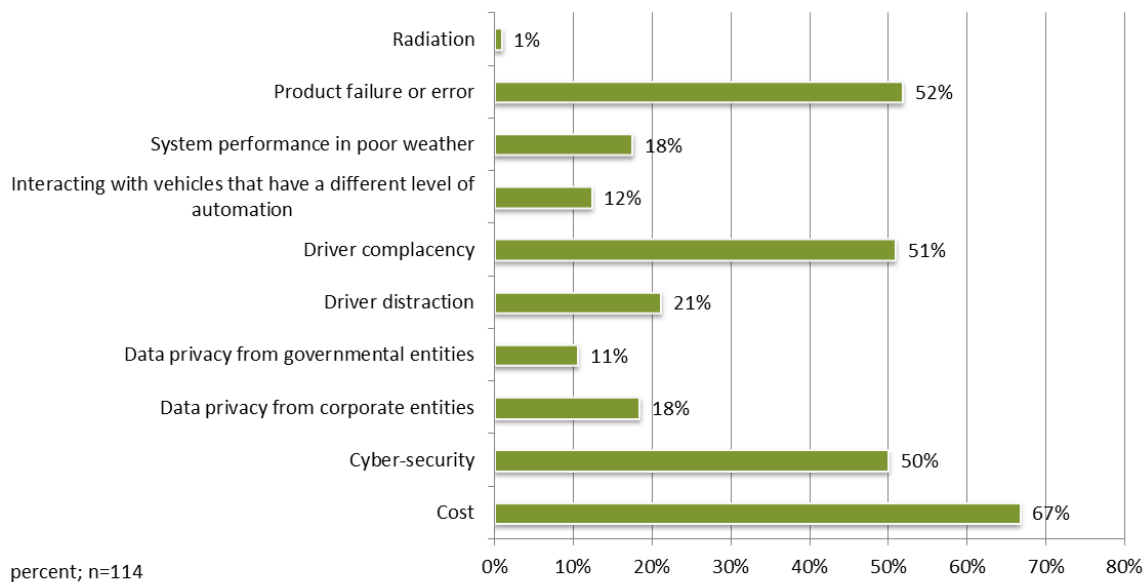


4.7 CONCERNS WITH CAV TECHNOLOGY

Respondents were asked to list their top three concerns with CAV technology (see Figure 28).

Cost proved to be the highest concern with two thirds of the respondents selecting it. Cyber-security, driver complacency, and product failure/error were the next most commonly mentioned concerns at around fifty percent each. Radiation was the least concerning.

FIGURE 28: CONCERNS WITH CAV TECHNOLOGY



The results were analyzed more in depth and broken down by age, which revealed a few interesting differences.

Product failure was significantly less of an issue for 18 to 29 years old respondents. On the contrary, participants between 30 and 44 years were almost two times as likely to mention this aspect as a concern with CAV. The trend decreased with the two older age groups.

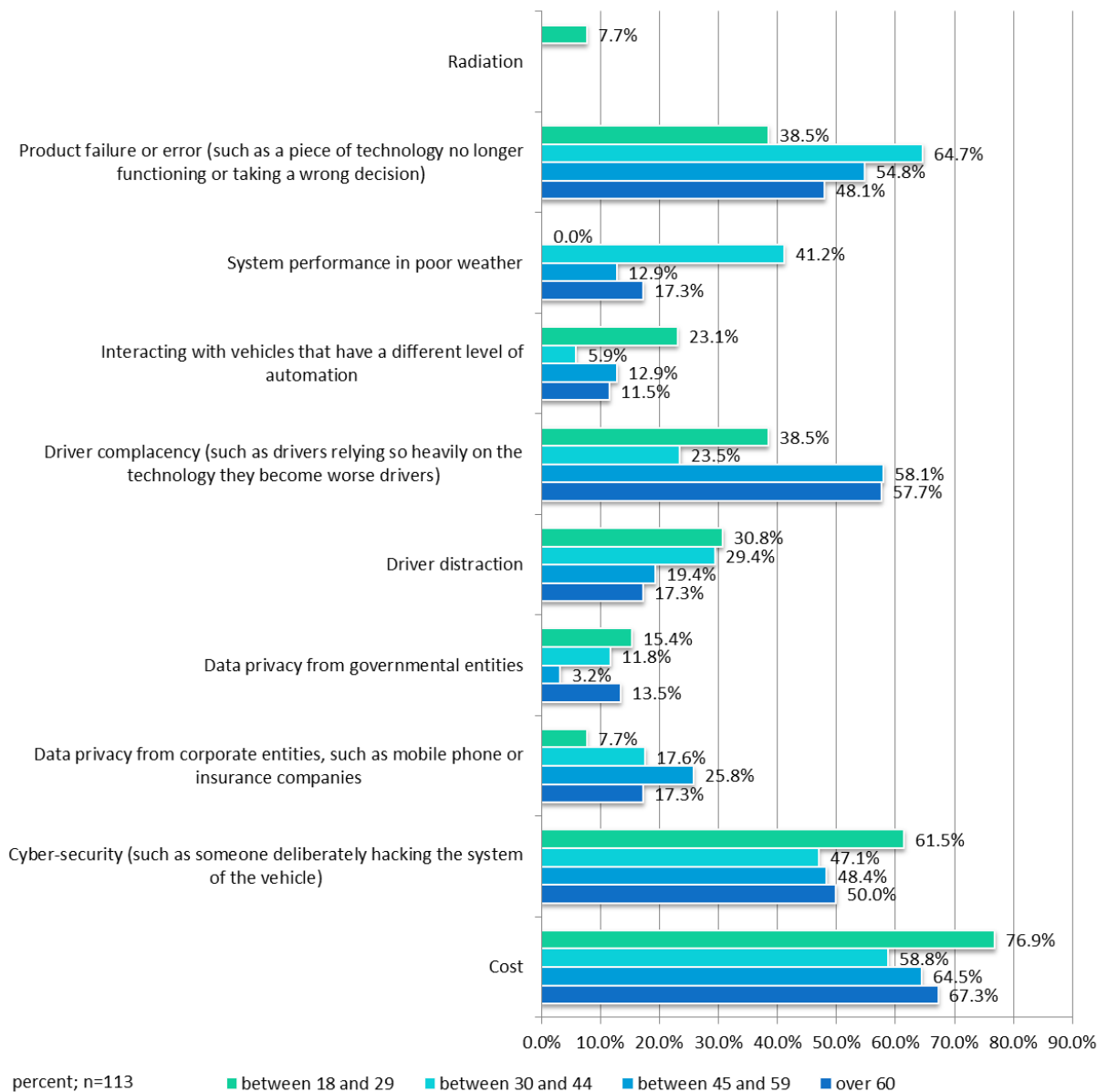
Thirty to forty-four years old participants were by far the group most concerned with system performance in poor weather. Forty-one percent of them stated this represented a concern with CAV technology.

Older participants, specifically those over 45 years, were relatively more concerned with driver complacency than the younger respondents were.

Around a third of participants under 45 years thought that driver distraction would be a problem with CAV, whereas less than 20 percent of older respondents agreed with the same statement.

Finally, respondents between 18 and 29 years were more likely to select cyber-security and cost as a top three concern with CAV than older participants were. For more details, see Figure 29.

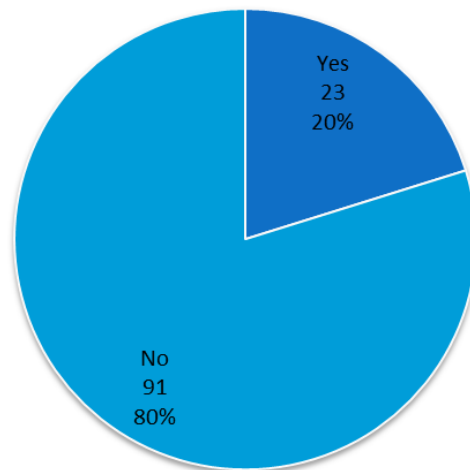
FIGURE 29: CONCERNS WITH CAV TECHNOLOGY, BY AGE



4.8 AWARENESS OF CURRENT AUTONOMOUS LAWS

The participants also were asked the question, “Are you aware that Michigan, Nevada, California, and Florida already have passed laws regarding the testing, operation, and sale of fully automated vehicles within the respective states?” A large majority of respondents (80 percent) noted they were not aware of that. Thus, data indicate public knowledge of state legislation on autonomous driving is limited (see Figure 30).

FIGURE 30: AWARENESS OF AUTONOMOUS VEHICLE LAWS



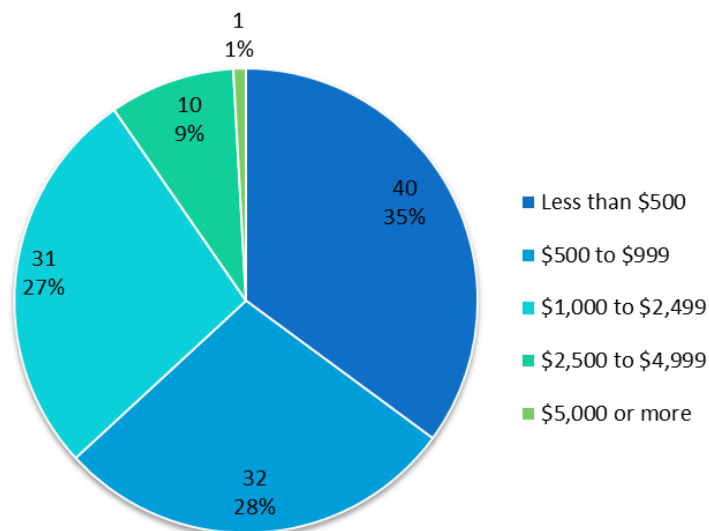
count and percent; n=114

4.9 WILLINGNESS TO PAY FOR CAV FEATURES

Given cost of CAV features was one of the primary concerns for respondents, it is not surprising that, in general, respondents were not willing to pay much more in order to have these features on a vehicle.

More than a third of respondents stated they would pay less than \$500. An additional 28 percent were willing to pay between \$500 and \$999 for CAV features. Only ten percent responded that they would pay more than \$2,500 (see Figure 31).

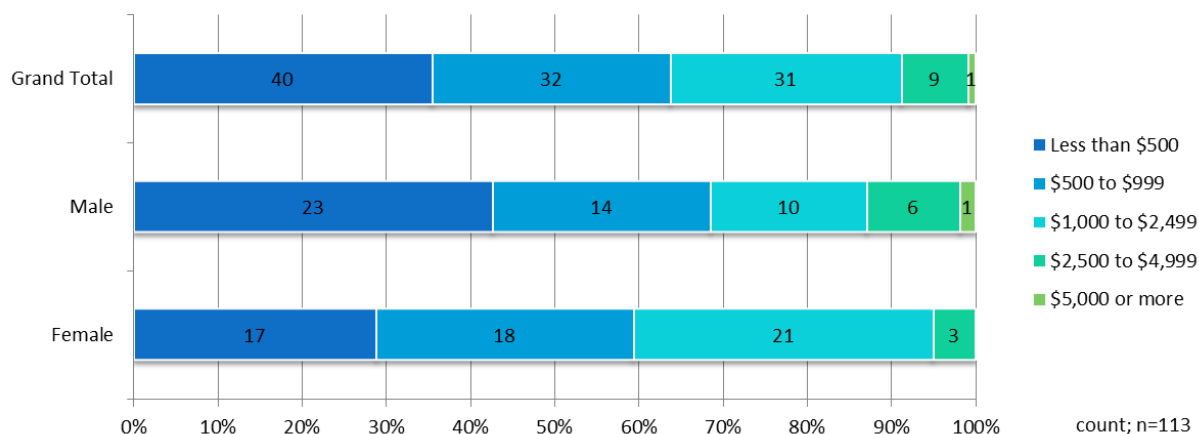
FIGURE 31: WILLINGNESS TO PAY FOR CAV FEATURES



count and percent; n=114

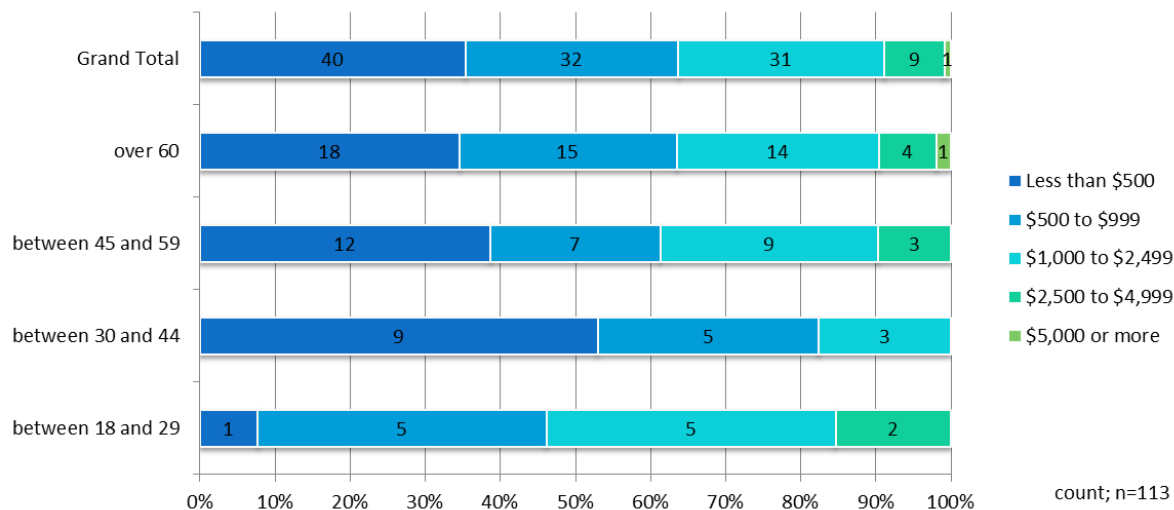
When the results were analyzed by gender, some differences appeared between the attitudes of women and men participating in the survey. Overall, men were willing to pay less for CAV features than women. Precisely, 43 percent of the male participants stated they were willing to pay less than \$500, whereas only 29 percent of the women expressed this opinion. Conversely, 41 percent of the women were willing to pay over \$1000, whereas only 31 percent of the men would pay that additional amount for CAV technology (see Figure 32).

FIGURE 32: WILLINGNESS TO PAY FOR CAV FEATURES, BY GENDER



The analysis by age revealed that the 30-44 years age group is the most reluctant to pay for CAV features. Specifically, more than half of these participants answered they are willing to pay less than an additional \$500 for this type of technologies. Conversely, the youngest category of participants (18-29 years) were the most open to paying more to have these features on their vehicles; more than half of them were willing to pay \$1000 or more (see Figure 33).

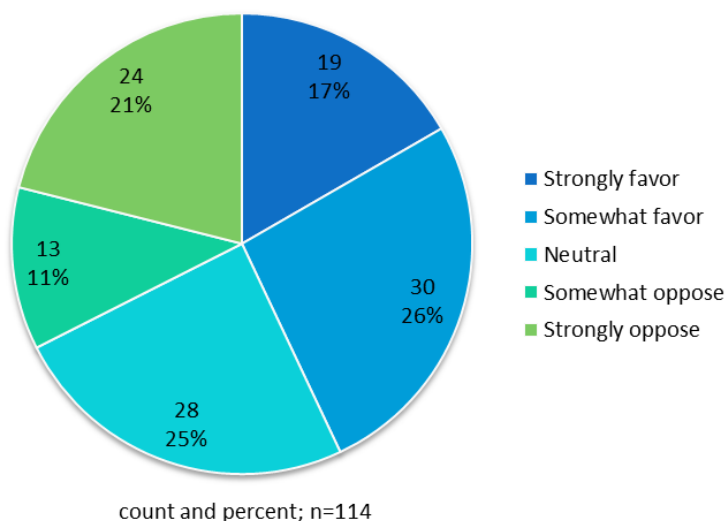
FIGURE 33: WILLINGNESS TO PAY FOR CAV FEATURES, BY AGE



4.10 SUPPORT FOR MANDATORY CRASH AVOIDANCE TECHNOLOGY

Respondents were generally mixed on their support for government-imposed requirements to make crash avoidance technology mandatory. Forty-three percent somewhat or strongly support the idea, while thirty-two percent somewhat or strongly oppose it. A quarter of respondents were neutral, indicating they did not have a strong opinion on whether these requirements should be mandatory (see Figure 34).

FIGURE 34: SUPPORT FOR MANDATORY CRASH AVOIDANCE TECHNOLOGY



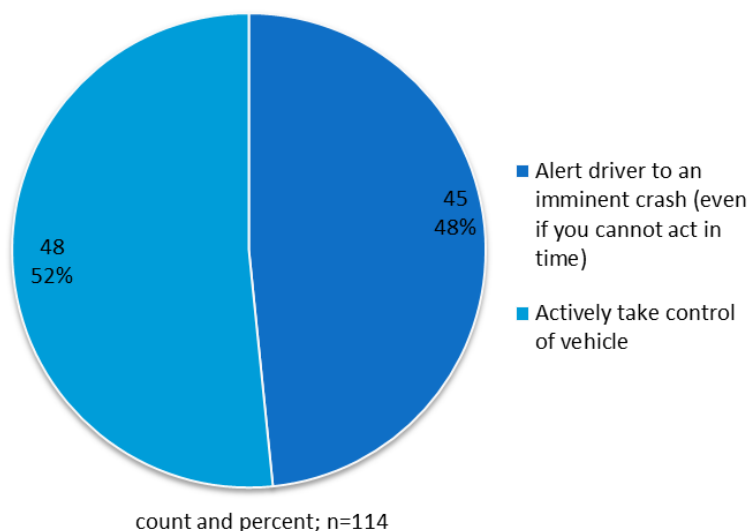
4.11 CONFIDENCE IN CAV TECHNOLOGIES AND SYSTEMS

Respondents were asked several questions that reflect their general confidence or their comfort level with CAV systems. The questions and responses follow.

PREFERENCE FOR VEHICLE TO TAKE CONTROL IN CRASH

When asked whether, in the event of an imminent crash, a respondent would prefer the vehicle alert him/her of the situation but not take an active role in preventing a crash or take an active role in crash prevention, respondent answers were fairly even. Only slightly more respondents – fifty-two percent – desired the vehicle to actively take control and prevent a crash compared to forty-eight percent preferring an alert (see Figure 35).

FIGURE 35: PREFERENCE FOR VEHICLE TO TAKE CONTROL IN CRASH



Respondents were asked to explain their answer, and eighteen chose to do so. Of those who said they would prefer an alert, the rationale tended to be around mistrust that a computer would, in all situations, have better judgment than a person. One person commented “there is no way to program a car to make decisions that might hurt [others].” Another said, “As the driver, I take control of the situation and not rely on [a] computer to work and do the right thing at the right time.”

For those preferring the car to take control to avoid a crash, it was in the pretext of ensuring the vehicle can accurately do that. “If the vehicle systems can consistently and accurately avoid a crash I would certainly favor that technology.” One commented s/he was ok with the car braking on its own, but not steering.

Four people commented they would like some blend of the two technologies, suggesting an override function would be valuable in case the car takes control but the situation requires human judgment. One commented “[I] would like an override on the control... many accidents involve 2 people and complex environments... sometimes that calls for human judgement/instinct.”

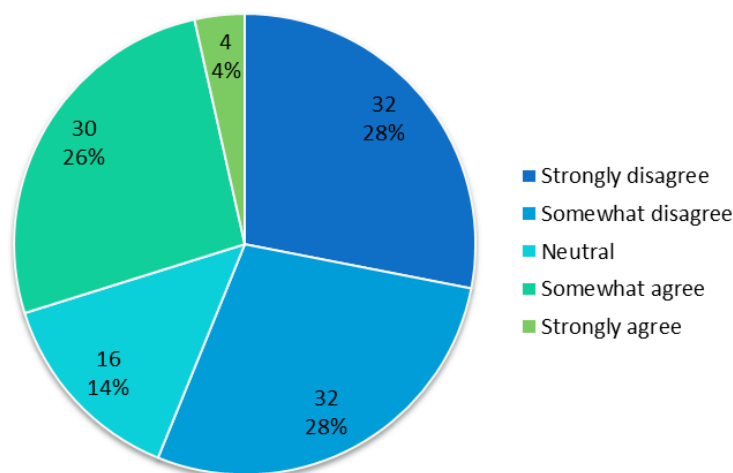
Two people commented they would like to know more about CAV in order to make an informed decision.

TRUST THAT COMPUTER CAN DRIVE VEHICLE

Respondents were asked the question “What is your opinion of the following statement? ‘I trust that a computer can drive my car with no assistance from me.’”

Just over half of respondents (56 percent) either somewhat or strongly disagreed with this statement. Forty percent somewhat or strongly agreed with the statement, and fourteen percent were neutral (see Figure 36).

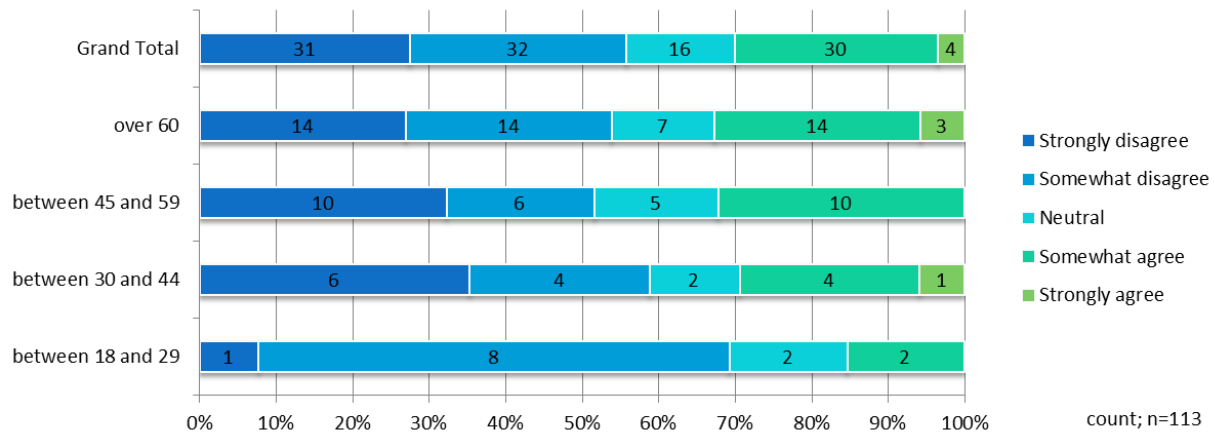
FIGURE 36: TRUST THAT COMPUTER CAN DRIVE VEHICLE



count and percent; n=114

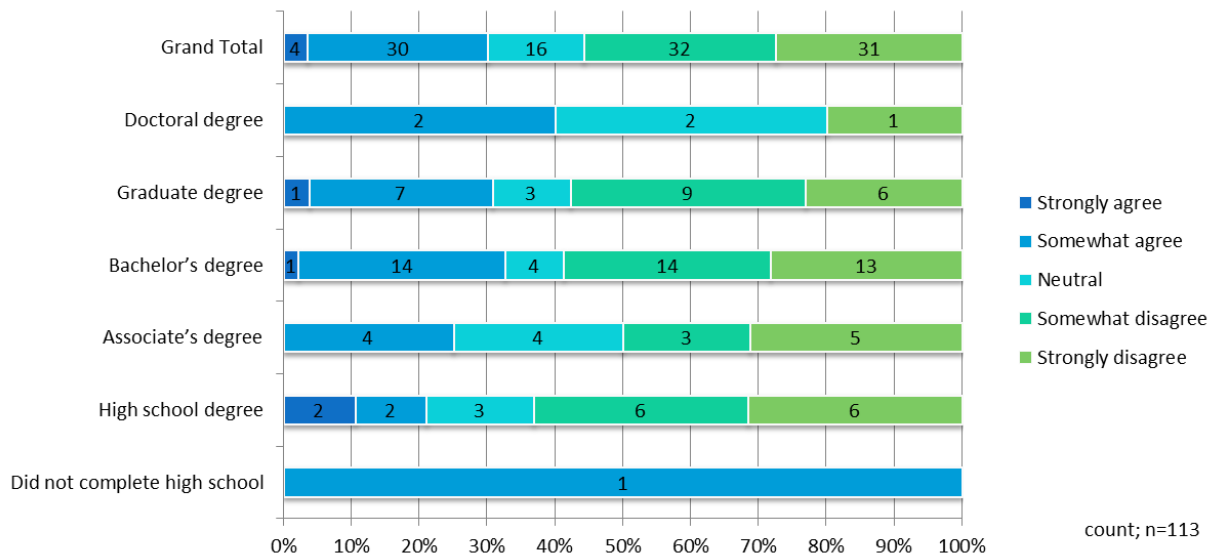
A detailed analysis by age revealed a few of interesting differences. Participants between 18 and 29 were least likely to trust self-driving technology. Specifically, 15 percent of the respondents in this age group strongly or somewhat agreed with the statement, whereas double the percentage of participants in the other three categories did so. For more details, see Figure 37.

FIGURE 37: TRUST THAT COMPUTER CAN DRIVE VEHICLE, BY AGE



Finally, increasingly lower trust levels in a computer’s ability to drive a vehicle were associated with participants that have higher levels of education (see Figure 38).

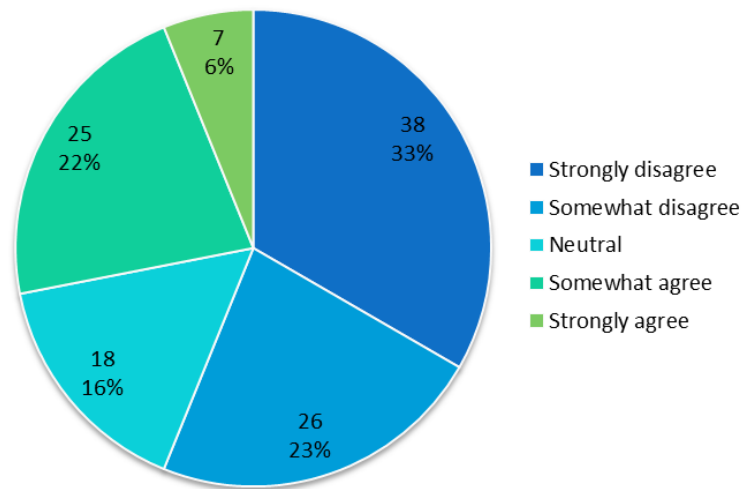
FIGURE 38: TRUST THAT COMPUTER CAN DRIVE VEHICLE, BY EDUCATIONAL ATTAINMENT



TRUST FAMILY MEMBER IN FULLY-AUTOMATED CAR

To the question “What is your opinion of the following statement? ‘I would be comfortable entrusting the safety of a close family member to a fully automated car,’” only 28 percent of respondents somewhat or strongly agreed. A majority – 56 percent – somewhat or strongly disagreed, and 16 percent were neutral (see Figure 39).

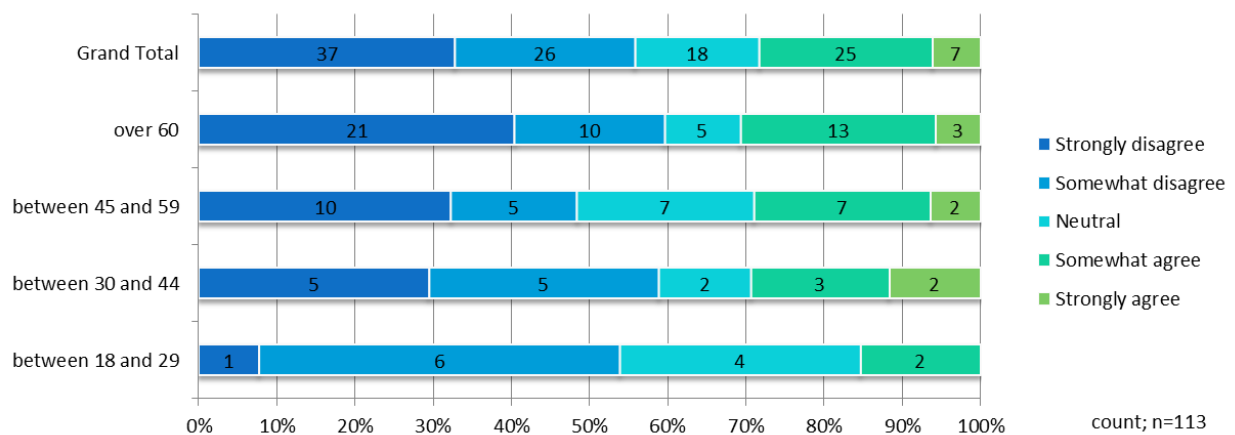
FIGURE 39: TRUST FAMILY MEMBER IN FULLY-AUTOMATED CAR



count and percent; n=114

As with the previous question, the analysis by age revealed an important trust difference between the 18-29 years group and the other participants. The youngest age group was two times less willing to entrust a family member to self-driving vehicle than the other older participants. Fifteen percent of 18-29 years old participants strongly or somewhat agreed with the statement, compared to compared to thirty percent of the other participants. For more details, see Figure 40.

FIGURE 40: TRUST FAMILY MEMBER IN FULLY-AUTOMATED CAR, BY AGE



count; n=113

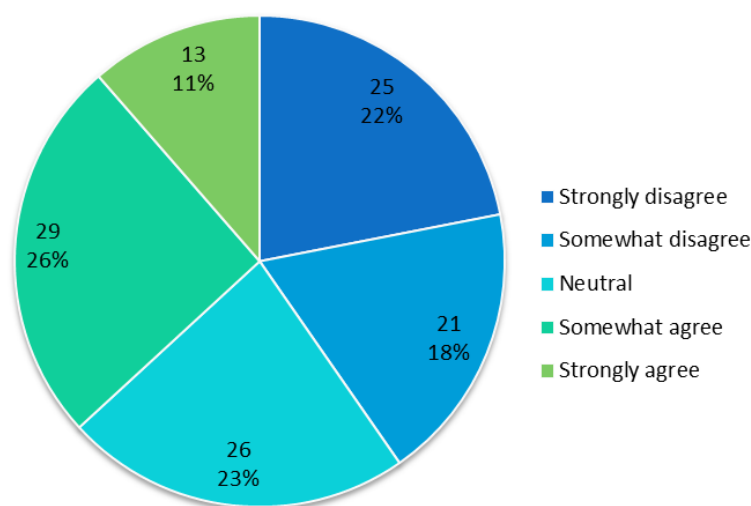
LEVEL OF COMFORT WITH DATA SHARING

Participants were finally asked the question “What is your opinion of the following statement? ‘I would be comfortable allowing my car to transmit encrypted data, such as its current location and speed, to surrounding cars in

order to better coordinate its path with those cars and keep me safe from crashes.””

Two times more participants were strongly opposed (22 percent) to transmitting data to surrounding vehicles (V2V), than the ones that were strongly in favor (11 percent) of that. However, thirty-one percent of respondents somewhat or strongly agreed and forty percent somewhat or strongly disagreed. This represents a relatively even split among respondents for this question. Twenty-three percent of respondents were neutral on the issue (see Figure 41).

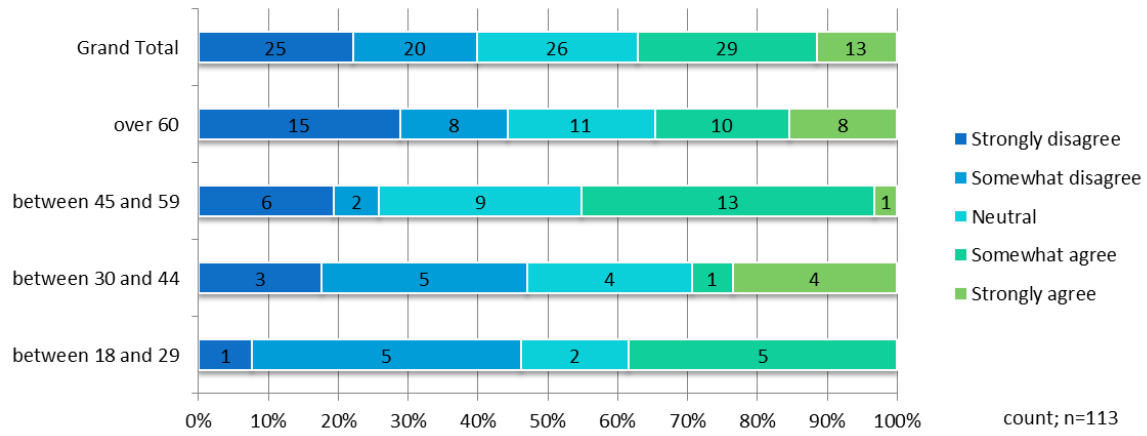
FIGURE 41: WILLINGNESS TO SHARE TRAVEL DATA



count and percent; n=114

The older the participants, the less they were comfortable with sharing data. Almost 30 percent of the participants over 60 strongly disagreed with the statement aforementioned, whereas less than eight percent of the youngest age group did so (see Figure 42).

FIGURE 42: WILLINGNESS TO SHARE TRAVEL DATA, BY AGE



5 DISCUSSION, RECOMMENDATIONS, AND PUBLIC COMMUNICATION PLAN

Connected and automated vehicle technology has the potential to disrupt not only the automotive industry, but also transportation options and mobility behaviors as a whole. The current period is rich in strategic realignments of automotive and mobility players, research efforts and development of new products and applications.

In parallel with the development and testing of new technologies, industry players, stakeholders and public authorities are increasingly interested in understanding in what way the general public will perceive, react to, and use CAV technology. In the past few years, an increasing number and variety of universities, public bodies, and research centers have started investigating public perceptions of CAV. Therefore, CAR conceived its research as an integral part of this growing body of work, giving particular attention to the USDOT Driver Acceptance Clinics (2012), the surveys of test drivers that participated in the Connected Vehicle Safety Pilot program (2013), and the public comments on connected vehicle technology and a potential V2V mandate for new light vehicles published by NHTSA in 2014.

For the Michigan Department of Transportation, up-to-date knowledge on the public perceptions of CAV can be crucial in informing policy choices (e.g., privacy and data sharing) and investment choices (e.g., infrastructure related to V2V and V2I applications). In addition, the results of this research could prove useful in programs aiming at improving road safety linked to driver behavior. Finally, MDOT can use these insights on public preferences and perceptions on CAV to better inform the general public and design better public information tools and materials on these technologies. An ensuing benefit from making public part of the results on the research would be an increased visibility for MDOT.

Building upon its previous work conducted in 2012, the Center for Automotive Research conducted a connected vehicle V2I demonstration and a web-based survey in order to assess public perceptions of CAV technology. The connected vehicle V2I demonstration took place in the Detroit connected vehicle test bed and involved six participants unexperienced with CAV technology. After the demonstration, CAR interviewed the subjects on their perceptions, trust and interest in using the technology. In general, the participants had a positive impression of the technology, but also expressed

concerns linked to the immature state of technology, data privacy, and cost. The subjects also mentioned that the state has an important role to play in promoting advanced automotive technologies for safety, mobility, and economic development.

The CAR researchers designed a web-based survey to gather quantitative data on the perceptions of the U.S. population of CAV technology. The participants were asked about their impressions, experience, interest, and confidence in CAV technology, as well as about the benefits and concerns with CAV. The sample of 114 respondents represented a population that was older, more educated, and wealthier than the average U.S. citizen. The results of the survey are generally encouraging. A solid majority of respondents (59 percent) had very positive or somewhat positive impressions of CAV technology. Participants had limited experience with most of the technology mentioned in the survey, but they manifested an interest in using CAV applications. However, despite having generally positive impressions of CAV technology, half of respondents showed little-to-no interest in owning or leasing a self-driving vehicle. For the participants in this survey, the biggest benefits of CAV technology were increased safety, improved emergency response to crashes, lower insurance rates, and parking and back-up assistance. The biggest concerns with CAV technology were cost, cybersecurity, driver complacency, and product failure/error. Given that the cost of CAV features was the primary concern for the survey participants, it is not surprising that, in general, respondents were not willing to pay much more in order to have these features on a vehicle (more than a third were willing to pay less than \$500). Respondents were also asked several questions that reflected their general confidence or their comfort level with CAV systems. Just over half of respondents either somewhat or strongly disagreed with the statement ‘I trust that a computer can drive my car with no assistance from me.’ In addition, more than half of the participants were somewhat or strongly reluctant to entrust the safety of a close family member to a fully automated car. Finally, two times more participants were strongly opposed (22 percent) to transmitting data to surrounding vehicles (V2V), than the ones that were strongly in favor (11 percent) of that.

RECOMMENDATIONS

The results of this research project show that public perceptions of CAV technology are dynamic, complex, and hold deep transportation policy

implications. It is therefore important to renew this type of research every one or two years in order to identify changes and constants in public perceptions.

- A sample of 400 respondents would increase reliability and representability of the results of the survey. Following the Survey Monkey guidelines (see Table 2)²⁴, in order to organize a survey aimed at the entire U.S. population and to obtain a margin of error of five percent on the results, the sample should have approximately 400 respondents.

TABLE 2: GUIDELINES FOR SURVEY SAMPLE SIZES

Population	Margin of Error			Confidence Level		
	10%	5%	1%	90%	95%	99%
100	50	80	99	74	80	88
500	81	218	476	176	218	286
1,000	88	278	906	215	278	400
10,000	96	370	4,900	264	370	623
100,000	96	383	8,763	270	383	660
1,000,000 +	97	384	9,513	271	384	664

Note: These are intended as rough guidelines only. In addition, for populations of more than 1 million, rounding up slightly to the nearest hundred is recommended.

- A sample that has roughly the same demographic characteristics as the general U.S. population would be more representative.
- In future surveys, an in depth analysis to determine whether the preferences of the respondents are correlated with their demographic characteristics would give a deeper understanding of the issue. As the results of the survey detailed in this report have shown, answers related to benefits and concerns varied the most with the age of the respondents. The willingness to pay extra for CAV features varied with age and gender, but there was not a distinctive trend according to income or education. Trust issues were correlated with age and education, but not so much with gender. Future surveys should seek to see if the same correlations reappear or whether new ones emerge.
- For future surveys, to enable tracking the evolution in perception, some questions should remain unchanged. The results obtained in previous years

²⁴ Source: Survey Monkey website, <https://www.surveymonkey.com/mp/sample-size/>

could then be used to analyze a topic in more depth and over time and could to adding new questions that dig deeper into topics that emerge as important.

- In the design of future focus groups and V2I or V2V demonstrations, the results from surveys should be used to identify particular system attributes to test (e.g., specific applications or technologies to test, traffic situations to simulate, etc.).

PUBLIC COMMUNICATION PLAN

Developing a short publication for the MDOT website based on some of the most interesting and important results of the survey would increase the visibility of this topic. In addition, it would be worthwhile to consider other outreach channels towards the greater public for the results of this study (e.g., media, conferences, etc.). This would improve the dissemination of information towards the Michigan population. As the results of the survey showed, public knowledge of state legislation on autonomous driving is limited. Finally, the results of this research also should be disseminated within MDOT to maximize their influence on transportation policy.

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APPENDIX A: LIST OF ABBREVIATIONS

BSW/LCW	Blind Spot Warning + Lane Change Warning
CAMP	Crash Avoidance Metrics Partnership
CAR	Center for Automotive Research
CAV	Connected and Automated Vehicle
DNPW	Do Not Pass Warning
EEBL	Emergency Electronic Brake Light
FCW	Forward Crash Warning
IMA	Intersection Movement Assist
LTA	Left Turn Assist
MDOT	Michigan Department of Transportation