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TECHNICAL REPORT

Driving with Partial Driving Automation Systems: Developing Effective Training that Drivers Will Use

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Title

Driving with Partial Driving Automation Systems: Developing Effective Training that Drivers Will Use

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Foreword

Technologies that automates certain aspects driving are becoming increasingly common in vehicles available to consumers in the United States and around the world. These technologies have the potential to make driving more comfortable and safer. Previous research by the AAA Foundation for Traffic Safety has shown the importance of ensuring that drivers understand the purpose, capabilities, and limitations of such technology, and that such understanding can be improved through training. Drivers will not benefit from training, however, if they do not use it.

This report presents the results of research that sought to determine how training intended to educate drivers about the technologies in their vehicles should be designed to maximize the likelihood that drivers will actually use—and thus benefit from—the training. The research team utilized an expert workshop, focus groups, and an on-road experiment to generate findings presented in this technical document. This report should be of interest to automobile manufacturers, driver education professionals, human factors researchers, and other stakeholders interested in promoting safe mobility.

The research described in this report was conducted under a cooperative agreement between the AAA Foundation for Traffic Safety and the Virginia Tech Transportation Institute.

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

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Executive Summary

Technologies that partially automate some aspects of driving are becoming increasingly common in vehicles. These technologies have the potential to make driving more comfortable and possibly safer. However, it is important for drivers to understand the capabilities as well as the limitations of these technologies in order to use them safely. Previous research has shown that formal instruction improves drivers' understanding of these technologies; however, most drivers do not seek nor receive formal instruction. Instead, most drivers learn mainly by trial and error.

This project employed a multi-phased approach, centered on principles of adult learning and motivation outlined in the ARCS Model of Motivation (Keller, 1987) to investigate features of formal training that would increase the likelihood that drivers would choose to engage with and complete the training. First, the research team held a workshop to solicit input from a multidisciplinary group of experts on a variety of possible approaches to training. Next, concepts were developed for several different approaches to training. Drivers' reactions to these training approaches were then assessed in focus groups. Finally, an on-road experiment was conducted to investigate drivers' actual engagement with various forms of training materials that were made available to them.

Method

A one-day workshop was convened to gain insights from a multidisciplinary group of experts regarding the most promising approaches to fostering driver engagement in formal training about partial driving automation technologies in vehicles. Prior to the workshop, the research team developed four training concepts:

1. A booklet or flip-book
2. A video played on a screen in the vehicles' center stack while the vehicle is parked
3. An in-vehicle demonstration by a live person
4. Interactive in-vehicle training designed to be performed while driving

Workshop participants' general perspectives regarding training content, delivery mode, potential efficacy, and knowledge gaps, as well as their reactions to these training concepts, were gathered through presentations, discussion, and breakout groups. Results were used to develop draft training modules.

Next, four focus groups were conducted with drivers who owned vehicles equipped with partial driving automation systems. The focus groups investigated participants' experience learning to use partial driving automation systems, their general thoughts on training for such systems, and their reactions to the draft training modules.

Finally, an on-road study was conducted to assess drivers' voluntary engagement with training in a realistic setting. The training modules were informed by the previous phases of the project. Participants were recruited for a study in which they were told they would drive a new electric vehicle. They were instructed to drive a 2023 Ford Mustang Mach E (which they were told was a prototype vehicle being studied) on a simple 107-mile route and to use the vehicle's partial driving automation system. Training materials developed by the research team were made available, but participants were not explicitly instructed to use them. Half of the participants had access to an in-vehicle video that could be watched while the vehicle was parked. The other half had access to a series of short interactive training messages, which the driver was invited to play at preset locations along the route. All participants also had access to a simple flip book placed on the front passenger seat. Participant engagement with the training was assessed using in-vehicle cameras and other data collection tools as well as a post-drive survey.

Results

Results suggest that interactive in-vehicle training may be a promising approach to increase drivers' engagement with formal instruction about safe and proper use of partial driving automation technology.

In the workshop, the experts highlighted the following:

- Strengths and weaknesses of each training approach, and the importance of capitalizing on the strengths of each one
- The importance of ensuring that any training approach is consistent with key principles of adult learning and motivation

In focus groups, participants had the following reactions:

- Reported learning mainly through trial and error, and that they did most of their learning about the vehicle's technology in the vehicle itself and/or with family or friends
- Rejected the idea of an in-person demonstration (e.g., from dealership personnel), despite their preference for learning in the vehicle
- Expressed that they wanted training to be broadly available, self-paced, easy-to-use, and to improve the transparency of how the technology works

In the on-road study, results showed the following:

- Participants were significantly more likely to report using the interactive training than the video or the flip-book

- More than 80% of those who were given access to interactive training completed most or all of it, and the majority appeared to pay attention to it
- In the post-drive survey, the majority of participants (66%–74%) said that they would use each of the types of training examined if it were available in a rental car

Several limitations should be noted. Development of market-ready interactive in-vehicle training would pose many challenges. In this study, the research team took great care to ensure that the training would not be excessively distracting, plotted a fixed route expected to have only light traffic, and programmed the training to begin at specific locations deemed safe (e.g., driving straight, no merging traffic). Such safeguards would be important but challenging to implement in a more general use case. While the study attempted to create a realistic setting to examine drivers' voluntary engagement with training, more research is needed to determine the extent to which drivers would actually engage with similar training in a true real-world context. Finally, this research focused on measuring drivers' engagement with training; training efficacy was not examined and requires additional research.

Introduction

Advanced driver assistance systems (ADAS) are becoming increasingly common in the U.S. vehicle fleet, and ubiquitous on new vehicles. The Highway Loss Data Institute (HLDI, 2024) estimates that more than 28% of registered vehicles in the United States in 2023 were equipped with automatic emergency braking technology and that more than 90% of model year 2023 new vehicle series included automatic emergency braking as a standard or optional feature. Systems designed to prevent the vehicle from leaving the travel lane, detect pedestrians, and alert the driver to the presence of other vehicles in the driver's blind spot are becoming similarly prevalent as well.

Systems capable of partially automating the driving task for an extended period of time are less common at present but are rapidly entering the market. Such systems, described by SAE International Standard J3016C as Level 2 (L2) Driving Automation (SAE International, 2021), are designed to assist or support the driver. Typically designed for use in limited-access highway environments, they comprise adaptive cruise control (ACC) in conjunction with lane centering (LC) systems, which keep the vehicle in its travel lane and control its speed and following distance from a lead vehicle. Although only an estimated 5% of registered vehicles in the United States in 2023 were equipped with such systems, they were available as a standard or optional feature on more than half of all new vehicle series in model year 2023 (HLDI, 2024).

When driving with the assistance of L2 partial driving automation the driver remains ultimately responsible for the safety of the vehicle and is explicitly required to identify and respond to any hazards that may arise. Nonetheless, the use of such technology changes the nature of the driver's engagement with the vehicle and the roadway environment in a fundamental way. Concerns have been raised that drivers may misunderstand these systems, potentially overestimating the capabilities of the systems and becoming overly comfortable engaging in non-driving-related tasks while using them (e.g., Mueller et al., 2024). Considering the increasing proliferation of vehicles equipped with L2 partial driving automation, it is important to ensure that drivers sufficiently understand the systems to support safe and appropriate use.

Previous research has shown that a driver's understanding of new technology is important in guiding safe use of the systems (e.g., Gaspar et al., 2021), but much less is known about how drivers develop their understanding of new technology. Manser et al. (2019) compared driving performance with L2 automation system features after participants received training in the form of (a) reading a manual, (b) active demonstration by an expert, or (c) a multimedia presentation of L2 automation system information. The results suggested that all of these types of information regarding ADAS were beneficial to participants. Additionally, such training improved driver cognitive workload and visual scanning with systems active. These results corroborate previous findings from Reyes et al. (2017) and McDonald et al. (2018), suggesting that any training is better than nothing.

While obtaining any training about L2 automation system appears to produce positive outcomes, it is unclear whether drivers will independently engage with it. Jenness et al. (2008) surveyed owners of vehicles with various advanced safety systems and found that a large proportion reported having not read the owner's manual to learn about the safety systems onboard the vehicle. McDonald et al. (2018) similarly surveyed early adopters of vehicles with then-new L2 automation system technologies and found that while the owner's manual was the single most common source of information consulted by owners to learn about the L2 automation systems, fewer than half of owners reported having consulted it. Many reported learning by trial and error or making no effort to learn about the systems; very few reported learning from other sources of information such as the manufacturer's website or other online sources. Thus, it appears unlikely that large numbers of drivers would take the initiative to seek out external resources to learn about the safety or driver support features in their vehicle.

When acquiring a new vehicle from a dealer, the quantity and quality of information or training offered by the dealership has been found to vary greatly (e.g., Abraham et al., 2017). Previous research using focus groups found that over 75% of participants received some form of L2 automation system instruction at a dealership but less than 17% reported the instruction was formal (Lubkowski et al., 2021). The same study found that participants who received formal training reported that it was more effective than those who received informal training (Lubkowski et al., 2021). Similarly, another study indicated that few respondents sought technology information outside of the dealership, the owner's manual, or their own experiences using trial and error (McDonald et al., 2018). The same work also found that one-in-ten drivers reported utilizing the internet to gain information and few utilized government websites for information on technology (McDonald et al., 2018). These results posit that dealership training may be effective but may benefit from formal methods that remove the possibility of lack of skill or understanding in the trainer and also assure consistency to all trainees.

Many vehicles, however, are purchased used and often not from a dealership, in which case dealer-provided formal training would be unavailable. In a survey of owners of new and used vehicles equipped with an L2 automation system, Reagan et al. (2023) found that used vehicle owners were less likely than new vehicle owners to be able to explain L2 automation system technology, such as blind spot warning or adaptive cruise control. Additionally, research has found that roughly two-in-five vehicles involved in fatal crashes were being driven by a person other than the registered owner of the vehicle at the time of the crash (Tefft et al., 2019). In the context of ensuring that drivers understand safety and driver support systems onboard a vehicle, these observations point to the need for training available outside the dealership as well.

Drivers may also engage in self-learning training methods. Lubkowski et al. (2021) reported that over half of the participants utilized either trial and error or the owner's manual to learn and gain familiarity about their L2 automation systems. Participants reported using trial and error learning methods either under normal driving conditions or on longer road trips versus their normal workday commute (Lubkowski et al., 2021). These results indicated that drivers engaged in training at times convenient for them, with low pressure from external forces and when they had extended periods of time to use L2 automation systems. Similarly, participants reported referring to the owner's manual on an as-needed basis versus reading the manual in its entirety and also reported that owner's manuals did not tailor content to the vehicles specific trim package, causing confusion (Lubkowski et al., 2021). These findings indicate that though training exists through dealerships and owner's manuals, drivers may still learn the features as they drive through trial and error.

Due to the preference for trial-and-error learning, future training may benefit from accounting for and designing methods to support drivers' learning by trial and error. This is especially germane as past research has found that, while practice and exposure to the system—effectively trial and error—can improve a driver's knowledge and understanding of their L2 automation systems over the first 6 months, they still do not reach the same level of comprehension as drivers that receive brief formal instruction on the systems (Carney et al., 2022).

Given that formal training has been shown to lead to better informed drivers, and given that typical adult drivers are not generally required to attend formal driver education classes other than in special circumstances (e.g., when legally required due to citations received for moving violations), there is an important but difficult problem of how to motivate adult drivers to engage with a training program.

The research team looked beyond driving research to examine the literature on motivation to engage with training and adult pedagogy. Much of the literature on adult learning is grounded in classroom experiences, which, while helpful, does not shed light on how adults choose to engage with a learning program in the first place. To understand motivation in an educational context, researchers turned to the ARCS model of motivation (Keller, 1987) for a theoretical framework. The four components of the ARCS Model are as follows:

- ***Attention***—To motivate learners, the first step is to gain their attention. The attention component involves presenting the training option long enough that learners can decide whether it is relevant to them.
- ***Relevance***—The second critical component of motivation is relevance. Learners must decide that whatever has gained their attention is relevant enough to explore. Relevance can be immediate or more far-reaching. Learners might find a training or learning experience relevant because it explains something about their lives, because peers are already

interested in it, because it might help them be safer, or because they will be graded on a task related to it. After learners see some relevance to their lives, their continued motivation depends on their confidence in the new skills, knowledge, or attitudes that the learning experience teaches them.

- ***Confidence***—The third component of the ARCS model is confidence. Learners build confidence by practicing the new skill and getting positive feedback about their ability to master it. For example, a learner may take one look at a training option that seems relevant, but then decide that they do not have what it takes to complete the learning task. Another learner may attempt it but be repeatedly unsuccessful. In either case, lack of confidence is responsible for the failure in motivation. With positive feedback, learners gain confidence in their ability to meet the objective.
- ***Satisfaction***—The final component is satisfaction. To leave the learning experience with new skills, knowledge, or attitudes, the learners must be satisfied with their ability to apply the new information in new situations. Learners may not be satisfied if the new knowledge conflicts with their existing understanding in irreconcilable ways or if the new knowledge does not seem to work in other situations.

The ARCS model provides a helpful framework for organizing strategies for motivating learners. Research on adult pedagogy also frames the context in which adult learning occurs, as opposed to research on learning among minors. Some critical differences include how the adult learners have established independence and have greater past experience upon which they rely (Halpern & Tucker, 2015). In developing tutorials for adult learners, Halpern and Tucker (2015) posited the following:

- Adult-centered tasks are highly relevant to a problem—instruction needs to be focused on necessity and specific to a task
- Adult-centered instruction is problem based—students should be allowed to explore solutions to a problem and not be told the solution, which allows for better application of the solution in broader context
- Adult-centered instruction acknowledges the learner's prior experience—the learner's past experience needs to be integrated into solutions
- Adult-centered instruction is self-directed—respecting that adults are responsible and independent thinkers, they should be allowed to obtain and interact with training in self-paced manner

These design principles nicely complement the ARCS model (Keller, 1983) described above.

In summary, evidence suggests that proper understanding of ADAS leads to safer interactions with the systems (Gaspar et al., 2021), and that formal instruction produces greater understanding than trial and error alone (Carney et al., 2022). Additionally, engaging adults into learning about a new technology may require special design considerations for adults, as well as motivational frameworks. It would likely be beneficial to offer formal instruction on L2 automation system outside of a dealership setting both because training provided at the dealership may be of inconsistent quality (Abraham et al., 2017) and because vehicles are often driven by persons who likely were not involved in the original acquisition of the vehicle from a dealer (Tefft et al., 2019; Reagan et al., 2023). Given drivers' clear affinity for trial and error (McDonald et al., 2018; Lubkowski et al., 2021) and the tenets of the ARCS model (Keller, 1983), it is plausible that drivers might be more likely to engage with formal training if it is offered inside the vehicle itself, so that they could access it at the place and time when they were seeking to learn/understand/use the vehicle systems. However, it is unknown whether drivers would engage in training to gain understanding of these new systems, even if readily available in the vehicle.

The current study employed a multi-phased approach to investigate features of formal training that would increase the probability of driver engagement with the training and effectively impart the key information that drivers need to interact safely with the L2 automation system. This project was completed in three phases whereby each phase of the project built upon information gleaned from the previous phase(s). Phase 1 focused on gathering qualitative data from experts via a workshop to guide the development of training materials about the use of an SAE Level 2 partial driving automation system. In Phase 2, focus groups were conducted with drivers to assess their reactions to these draft materials and refine them based on insights from the focus groups. Finally, an on-road study was conducted to investigate drivers' actual engagement with the training materials in a quasi-naturalistic setting.

Chapter 1: Expert Workshop

A one-day expert workshop was convened in Arlington, Virginia, to gain insights from a multidisciplinary group of experts regarding the most promising approaches to fostering engagement among drivers in formal training about L2 partial driving automation technologies. The workshop focused on training content for both novice and experienced drivers using L2 partial driving automation technologies. Through presentations, discussion, and breakout groups, participants' perspectives regarding the training content, training efficacy, and gaps in knowledge were gathered. The research team was present throughout to facilitate discussion and take notes.

Prior to the workshop, informed by the literature cited previously in the Introduction, the research team developed four distinct training concepts. As a part of the workshop, the research team elicited participants' reactions to these four training concepts. Major themes identified in the workshop were then used to guide the development of the targeted training modules in subsequent phases of the project.

Method

Participants

The research team identified and invited experts with backgrounds in fields directly relevant to driving/traffic safety, such as driver education and training, automobile manufacturing, vehicle technology, human factors of vehicle, public health, road safety research, and consumer product safety. In addition, because of the project's focus on driver motivations and decisions to engage in training, the research team also invited several experts in a diverse array of fields not explicitly related to driving, such as adult learning, instruction design, aviation safety, social media, and video game design. Participants from state and federal agencies were also invited to give their perspectives. The aim of the participant sample was to gather representatives from a variety of disciplines to provide a unique perspective on how drivers could be motivated to engage with training about vehicle automation and how training could be designed to maximize the likelihood of engagement. Fourteen of the invited experts ultimately attended and participated in the workshop.

Training Concepts

Prior to the workshop the research team developed four general concepts for potential types of training to explore. These focused specifically on types of training that could be administered inside of the vehicle itself, and included the following:

- A simple flip book or booklet
- An in-vehicle video

- An in-vehicle demonstration by a live person
- Interactive in-vehicle training

To avoid unintentionally biasing participants' thoughts or discussions, the research team did not bound each training type by providing formal definitions. The goal was to allow the experts to think freely and give their thoughts and opinions with minimal guidance or intervention by the research team.

Workshop Overview

Table 1 shows the overview of the workshop by section along with the approximate time allotted for each section.

Table 1. Overview of the Workshop

Workshop Section	Overview of Section	Time (Minutes)
Workshop Introduction	Welcome	10
	Logistics and participant introductions	20
	Project overview and training options	20
	Meeting objectives, team selection, and rules of the road	10
Workshop Breakout Sessions	Team breakout—rotating training approaches	30
	Break	10
	Team breakout—rotating training approaches	30
	Break	10
	Team breakout—rotating training approaches	30
	Break	10
	Team breakout—rotating training approaches	30
Lunch Break & Topic Wrap-Up	Lunch and interpret—pull out key points from each of the four groups	75
	What is missing?	30
Driver Engagement Discussions	Driver engagement is the key	20
	Team breakout driver engagement	40
	Break	10
	Driver engagement report from each team	20
	Driver engagement idea discussion and priorities	25
	What is the most important for this research?	25
Closing Thoughts Round Table	What's next?	20
	Closing thoughts	20

Workshop Introduction. To begin the workshop, members of the research team introduced themselves and explained the agenda. During the project overview and training options segment, two members of the research team presented information regarding SAE Level 2 partial driving automation systems, driving safety issues with these systems, and general research findings regarding how drivers learn to use these systems. The second member of the research team focused her discussion on adult learning and motivation focused on the ARCS model and the four training methods that will be discussed over the course of the day. Finally, an overview of the objectives and rules were provided after which participants were grouped into teams of five to six participants.

Breakout Sessions. The workshop was separated into four 30-minute breakout sessions. During each breakout session, teams discussed one of the training methods (see above). Participants brainstormed pros, cons, and any other ideas about each type of training. After each breakout session, one participant stayed behind as a moderator to help fill in any gaps or questions that the current group had about ideas from previous groups. After teams experienced all four training types, the workshop broke for lunch.

Lunch Break and Topic Wrap Up. During lunch, workshop participants sat at a table of their choice and were encouraged to pull out the key points from each training type and discuss their opinions and ideas. A spokesperson from each table was asked to present those points to the entire workshop. This allowed members of other groups to comment and give their opinions and suggestions. After the groups presented and all comments were made, the conversation shifted to what each type of training was missing. During this discussion, participants openly gave their opinions and thoughts about what was missing or needed in the four types of training. Throughout the whole session, multiple researchers took notes on the conversations.

Driver Engagement Discussions. The driver engagement discussions allowed participants to give their opinions and thoughts on how to get drivers engaged in L2 automation system training. Participants were encouraged to explore and mention anything that they felt could help motivate someone to complete the training. This discussion was then brought to the entire group to give insight into what the smaller groups felt was important and motivating.

Closing Thoughts Round Table. To close out the workshop, the research team explained the next steps to develop these training types. Once the training types were developed, the team planned to conduct focus groups to have users give their opinions on each training type, thereby gaining insight into the best uses for each, as well as positives and negatives about each type. Once these focus groups were completed, the research team would implement the training types and conduct a series of research studies. After closing thoughts from participants, they were thanked for their time and insights during the workshop and were dismissed.

Results

Data Annotation

Members of the research team first gathered all instructional materials and notes from researchers and participants. All notes were digitally consolidated and saved in a private folder accessible only by members of the research team. Main themes and ideas about training types and methods were pulled from the notes and documents for use by the research team in future phases of this project. Key takeaways from the workshop are categorized in the following section.

Key Takeaways from the Training Types

Flip-Book. Overall, participants felt that a flip-book's ideal training application would be situations where it serves as a quick reference or quick start guide. Such references or guides only contain priority information in smaller chunks to give a basic overview rather than full explanations. Flip books may benefit from containing commonly used information and the most common errors, which would target the largest population, as opposed to giving more nuanced information. Participants also felt that it may be more challenging to design appropriate and effective information in this form, as cultural and language barriers may exist. A possible suggestion for reducing cultural and language barriers may employ the types of approaches used in instructions by companies such as IKEA or Lego, which remove language from the instructions and rely only on symbology. However, this may present additional problems for more complex situations, such as with higher levels of automation. Due to inherent limitations of flip-books, multiple participants suggested that they could be used in conjunction with other forms of information or training.

In-Vehicle Demonstration. Multiple themes emerged from participants' responses about in-vehicle training. Participants identified the need for a high level of education for the in-vehicle trainer to deliver correct and accurate information to the trainee. This level of education is dependent on the quality of the trainer's work, including their desire to learn and to complete the training to the best of their ability, and the variability of approaches between types of instruction. All these aspects could cause inconsistency in in-vehicle training and possibly lead to negative repercussions for the trainee.

A second issue identified by participants was when and where such in-vehicle training would be delivered. The point of sale was thought to be the most probable option; however, there were questions regarding whether a purchaser would have the patience to complete additional training after having just completed the potentially lengthy purchase process. Relatedly, it might be beneficial in some respects for an owner of a new vehicle to take the vehicle home and experience the in-vehicle systems and features in the real world and then return for additional training. This would allow the trainee to ask more in-depth questions, as they will have more experience with L2 automation systems at that point. However, if training were offered at a future date rather than at the time of purchase, what proportion of purchasers would actually return to the point of sale for training? It was also noted that vehicles may be driven by other people besides the original purchaser, e.g., family members, friends, and potentially subsequent purchasers who buy the same vehicle later as a used vehicle.

To help mitigate some of the potential challenges discussed, participants mentioned multiple solutions. These included the use of standardized education and fidelity checklists to ensure information is delivered correctly and similarly across all trainers. The use of incentives was also suggested to help motivate trainees to return to the point of sale for additional training; these could include gift cards or other incentives. Participants also thought it would be beneficial for the training to be offered to teen drivers and their parents or guardians. This could allow for training multiple people at once and encourage trainees to return to the point of sale.

In-Vehicle Video. The in-vehicle video training option (e.g., available on the center stack when the car is not in motion) had multiple common points mentioned by participants. A key aspect participants noted was the ease of deployment and updating for many vehicles. Many production vehicles already have infotainment or navigation screens that would allow for drivers to select and watch videos. These videos would be easy to deploy and update at a dealership or even remotely. Another advantage noted by participants is that in-vehicle videos stay with the vehicle, in contrast to paper materials like an owner's manual or flip-book, which can be removed from the vehicle and lost. Videos could also be watched multiple times or by multiple drivers in cases such as rental fleets or multi-driver households.

Participants also identified cases where barriers or complications may exist. It may be difficult to track who has watched videos or to ensure the current videos are up to date if remote updates are not possible. Similarly, menu options may be difficult for drivers to navigate to locate the videos, especially if there are multiple videos to watch. It was also noted that keeping drivers engaged may be a challenge and thus that videos should be short.

Automated Interactive Training. The workshop identified multiple key points for the use of automated interactive training. Compared to other approaches, automated interactive training could be customizable to individual drivers and portable to future drivers. Automated interactive training also offers a natural interaction with drivers that can be voice activated, allowing a "call and response" between the driver and the system. Systems could be programmed with different personas, deliver immediate feedback, and deliver information in "bite-sized chunks" or short, succinct messages. Such training could potentially initiate after a driver has experienced an apparently unsuccessful interaction with the system, helping drivers to understand the capabilities and use cases of system features. Similarly, automated interactive training could adjust the information given based on driver knowledge, behavior, and preferences, which in turn could reduce distraction or startling of the driver. Interactive training could also cater to driver preferences, for example allowing drivers to choose when to initiate training, or postpone training based on situational factors such as the demands of the roadway and traffic.

Participants also noted several potential drawbacks of automated interactive training. Participants mentioned that if poorly implemented, such systems could potentially startle or distract drivers, for example if the system initiates training suddenly while the demands of the driving task itself are high. Participants also noted that the effectiveness of such training may be limited by drivers' desire to learn. For example, systems may have few means of assessing a particular driver's level of experience and thus may not be able to customize the training to drivers of different experience levels, especially in a vehicle that is driven by several different people.

Key Takeaways Regarding Driver Engagement

A common theme identified by participants was the question of how to motivate drivers to want to use training, including such concepts as the training value, relevance, and utility. Drivers will usually end up learning through trial and error, so the design of the training should support that. Participants expressed that use of on-demand learning, shortening the time between driver errors and when helpful information is provided, and transparency of the training algorithm would help learners engage, especially in conjunction with their use of trial and error. Adding other dimensions, such as allowing drivers to explain their thoughts and actions using a think-aloud option, could help in training and give insight into the driver's thought processes. Coupling with the think-aloud techniques, participants also mentioned that understanding and tailoring training to how drivers learn will help them engage and stay engaged in training. Participants noted that drivers may feel more inclined to engage in training if they were to get something tangible out of it (i.e., beyond the benefit of improving their understanding of the system). Participants mentioned that drivers may feel higher levels of motivation to complete training if given incentives, examples of which might include discounts on rental cars or insurance, or perks at dealerships, to complete training. Similarly, locking certain features until drivers complete training may also help motivate drivers engage in training. They may find added safety or convenience benefits in the system but would need to complete training to utilize it. It was noted, however, that this would be a challenge to implement in a shared vehicle.

Overall Guidance and Thoughts

Workshop participants also offered a variety of feedback that informed training at a general level, and not specific to a particular training type. Participants mentioned the importance of flexibility. Not every training method will be a fit for every trainee, so it is important to determine what works best for each individual or type of trainee and provide multiple options. Options could be available within each training type or could be provided by offering multiple types of training, such as using more visual- or audio-based training for varying levels of experience or understanding. To help design suitable training for as many people as possible, further research may benefit from using learning ecosystem frameworks to help guide decision-making and from recruiting participants with varying perspectives when testing (e.g., range of ages, levels of education/literacy, different levels of general driving experience, different levels of experience with vehicle technology and technology in general, etc.). It would also be beneficial to utilize a multi-pronged approach to training, delivering information in ways that different types of drivers will use. Training should also be personalized and there should be some means to detect whether drivers have completed the training. This could plausibly be implemented using features such as a "smart key," pairing the vehicle with the driver's smartphone, or other such means. Similarly, training should be offered at appropriate times—for instance, offering videos when the vehicle is stationary and parked or initiating interactive training when overall driving task demands are minimal (e.g., light traffic, uncomplicated roadway geometry) and the driver is in a familiar area. This would also help to convey system limitations, where drivers would learn to use systems only at appropriate times, helping to reduce misuse.

Participants appeared to have the strongest feelings about a few specific points for training. The first point was that training should not occur at just a single instance but rather should be an ongoing experience. Drivers should be able to learn more features when they are ready and be able to refer to training sessions that they have already completed. Participants also strongly felt that training must not be boring. Users will not have any desire to complete training if it is boring and may not even start it. This is also key with changing drivers' understanding to help them learn the correct system operations or to overturn previous incorrect understanding of the system's abilities and limitations.

Discussion

Overall, workshop participants expressed that each training type had strengths and weaknesses, and that each had potential, if used correctly. Participants also noted that using multiple forms of training and offering different training styles in conjunction with one another may offer promising results to a wider group of people, regardless of native language or level of knowledge. Similarly, participants believed that, regardless of training type, all training should be able to capture and hold the driver's attention, and that delivering information using short training methods would reduce confusion and avoid overloading the driver. Training should also be available at appropriate times and on multiple occasions so drivers can refer back to the training if needed or so that other drivers of the vehicle can access training if needed.

Though this workshop helped gather insights from several experts representing a wide array of expertise, background, and stakeholder groups, future work would benefit from interviewing or gathering the opinions of drivers of vehicles equipped with L2 partial driving automation systems, as well as those of drivers who are not familiar with such systems. Isolating and gathering information from each of these groups would help inform future training designs. Tailoring information so that novice users are motivated to engage with training and receive correct and helpful information would be advantageous. Also, it is also important to motivate more experienced users of such technology to engage with training that solidifies their proper understanding of system use cases and limitations.

Chapter 2: Focus Groups

A series of focus groups was conducted to investigate drivers' experiences learning to use L2 partial driving automation systems, their general thoughts on training for such systems, and to assess their reactions to four training concepts: a flip-book, an in-vehicle demonstration by a live person, an in-vehicle video, and an in-vehicle interactive training. The research team leveraged the ARCS model of motivation in planning the focus groups to determine how small groups of L2 partial driving automation system users had learned to use their systems and how drivers who are inexperienced with L2 automation systems should be trained to safely use those systems.

For the *attention* element of the ARCS model, researchers asked how drivers may be motivated to engage in and complete training, which also helped to understand barriers to training. For the element of *relevance*, researchers looked at how drivers relate learning and training to their own experiences, which affects training motivation, both positively and negatively. The element of *confidence* plays an important role in discovering factors of training that impact drivers' certainty or trust. This is true for both drivers' trust in the vehicle systems but also in their ability to understand those systems, which in turn may give important details that current training may be missing. Finally, with respect to *satisfaction*, researchers investigated drivers' satisfaction or their overall pleasure and enjoyment from the training experience. Researchers also explored those cases where the training did not meet drivers' needs, resulting in a lack of satisfaction.

Method

Four focus groups were conducted, each with seven or eight participants. Participants were drivers who owned vehicles that were equipped with L2 partial driving automation systems and that used them regularly. Discussions centered around various training types and how best to train inexperienced users of partial driving automation systems. The objective of the focus groups and subsequent qualitative analysis was to provide guidance to refine the development of the training modules and assess whether flip-books, in-vehicle demonstrations, in-vehicle videos, and interactive training should be further tested, combined, or removed from consideration in the current project. Because the focus of the project was to determine what types of training drivers would be most willing to use, rather than on training drivers about specific details of a system, focus groups discussed ACC rather L2 partial driving automation for the sake of simplicity.

Instead of testing hypotheses or research questions, the research team adopted an exploratory approach that sought to elicit participant responses about (a) their uses of ACC and learning strategies and (b) their opinions about the instructional strategies developed by the research team, as well as final thoughts outside the scope of the structured research questions. Each focus group was led by two researchers who served as moderators and guides for conversation.

Participants

To meet inclusion criteria for the focus groups, participants were required to be 18 years of age or older, have a valid U.S. driver's license, and drive a vehicle of model year 2018 or newer that is equipped with a partial driving automation feature. Specifically, each vehicle must have been equipped with both ACC and LC technologies. Participants owning or leasing vehicles with either ACC or lane keeping assist (LKA) alone were excluded from this study. To capture a diversity of driving environments, approximately half of the participants were recruited from the New River Valley in southwestern Virginia, and half were from the Greater Washington D.C. metropolitan area.

Recruitment for the focus groups utilized the recruitment team at VTTI. The recruitment team contacted previous participants from other studies and circulated ads for the study on social media. Participants who contacted recruitment team for the L2 automation system were screened for eligibility and, if they met the inclusion criteria and their schedules allowed, they were added to a focus group based on geographical location.

This study collected data from 30 participants from four focus groups, two groups containing seven participants and two groups containing eight participants. Fourteen participants identified as male, 15 identified as female, and one did not report their gender. Ages of participants ranged from 20 to 83 years old, with an average of 51.5 years old (SD: 17.8 years). The majority of participants (21 of 30) identified as White, four were Asian, two were Black, two were Hispanic or Latino, and one identified as multiple races. Five participants had a high school diploma or equivalent, 10 had a bachelor's degree, 14 had an advanced degree, and one opted not to disclose their level of educational attainment.

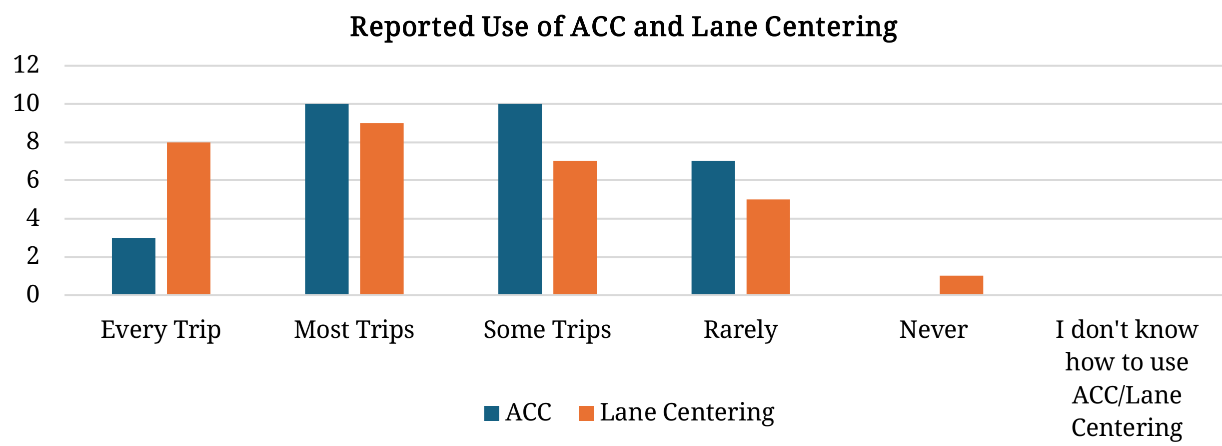
Participants were also asked to report various information regarding their driving experience. Participants reported having begun driving, on average, at age 16.7 years (SD 1.9 years) with a range of 14 to 25 years old; one participant did not report the age they began driving. Four participants reported having been involved in one crash in the past 10 years; the remainder reported no crash involvement in the past 10 years. A total of 22 violations were reported by 14 of the 30 participants, with a maximum number of four violations reported by one participant.

Basic vehicle information and system use was also gathered from participants. Table 2 shows the make and number of each vehicle brand. Vehicle model years ranged between 2018 and 2024, with three participants not reporting the year of their vehicle. Participants also reported the frequency of use of ACC and LC, shown in Figure 1.

Table 2. Brand and Number of Brands of Vehicles Owned by Participants

Vehicle Brand	Number
Acura	1
Alfa Romeo	1
Ford	1
Honda	4
Hyundai	3
Kia	2
Mazda	1
Nissan	1
Subaru	3
Tesla	6
Toyota	6
Volkswagen	2

Figure 1. Participants' Reported Use of ACC and LC (N=30)



Procedure

Two in-person focus groups were held at VTTI with participants recruited from the New River Valley area, and two virtual focus groups were held with participants recruited from the Greater Washington D.C. metropolitan area.

In-Person Focus Groups. Before the in-person focus groups, recruiters sent each participant an information sheet that explained the study's objectives, compensation, and risks; a unique identifier; and a survey to complete before the focus group. Participants then checked in to VTTI on the assigned day and were seated in a large conference room. Researchers then gave each participant a copy of the information sheet and a tax form, which they had to complete in order to receive compensation for the study. Once all participants arrived, a researcher gave an overview of the information sheet and asked each participant if they had any questions. Once all questions were answered and the tax forms were collected, each participant received a reloadable MasterCard that funds were added to by the researcher upon study completion.

Virtual Focus Groups. Participants who were scheduled for the virtual focus groups were sent the information sheet, a unique identifier, a DocuSign link to sign and return the tax form, a Teams Meeting Link for the focus group, and a survey to complete. Each was scheduled for a consent session before the focus group. In the 30-minute consent sessions, researchers went over the information sheet and participants were allowed to ask any questions. Once the consent session was complete and the participant had completed the tax form, a reloadable Mastercard was sent to the participant. Participants were asked to tell the recruitment team or researchers when they received the Mastercard so funds could be applied to it. If participants still wanted to participate, a member of the recruiting team scheduled them for the focus group session. At the scheduled time for the focus group, each participant signed into the Teams Meeting and was admitted by a researcher. Once all participants arrived, a researcher briefly went over the information sheet and asked participants if they had any questions before they began the focus group. Once all questions were answered, the focus group session began.

Equipment

To ensure accuracy and the ability to reference any questions in conversation, each focus group used the "record and transcribe" feature in Microsoft Teams. Upon completion of each focus group, a member of the research team removed any personally identifiable information and replaced any participant names with a unique identifier when possible. Transcriptions and recordings were then saved to a folder on a secure server located at VTTI. Coders at VTTI checked each transcription for accuracy.

Focus Group Session

Participants' Experiences. To begin each focus group session, the researcher started the recording and transcription, and informed participants that both had begun. A researcher began this section of the focus group by having participants introduce themselves and tell the group a story about an experience with ACC or another technology as an icebreaker exercise. After these introductions, a researcher gave a series of prompts about how people use and do not use ACC. Participants were encouraged but not required to respond and converse about each prompt. The following is a list of prompts used for this section:

- How did you learn to use adaptive cruise control?
- Why do you use adaptive cruise control?
- Why do you NOT use adaptive cruise control?
- How long did it take you to learn to use adaptive cruise control?
- Were there events that changed your learning ability/desire when using adaptive cruise control?
- How did you learn the limits of adaptive cruise control?
- Did you have different learning strategies for adaptive cruise control?

Researchers proceeded through each prompt, making sure to balance the pace for the time allotted, but also allowing each participant to respond. Once all prompts were complete, the researcher had participants take a short break before beginning the next section of the focus group.

Proposed Training Methods. To begin the second half of each focus group, researchers showed each training method (described below) to the participants. Researchers varied the order that participants were shown each training method (flip-book, in-vehicle demonstration, in-vehicle video, and interactive training) to help reduce bias. The order is shown in Table 3. After a training method was shown, participants were given the opportunity to ask researchers any clarifying questions. This continued for each training method until all four were complete.

Table 3. Order of Training Methods Shown to Participants During the Focus Groups

Focus Group Number	Training Methods			
Focus Group 1	Flip-book	Interactive	Video	Demo
Focus Group 2	Demo	Flip-book	Interactive	Video
Focus Group 3	Video	Demo	Flip-book	Interactive
Focus Group 4	Interactive	Video	Demo	Flip-book

Prompts About the Proposed Training Methods. After the final training method had been shared, a researcher went through a second series of prompts if participants did not cover each one in their previous responses. The list of these prompts is below:

- What would make you want to use some sort of training for adaptive cruise control?
- Which instructional strategy are you more likely to use? Why?
- What would make you NOT want to use some sort of training for adaptive cruise control?
- Are there instructional strategies outside of what you experienced that may make you want to experience training?
- Have you ever taught someone how to use adaptive cruise control?
- Which of these instructional strategies would you use to teach someone how to use adaptive cruise control?
- Where (location) would you use one of these instructional strategies?
- When throughout the ownership of a vehicle would you use one of these instructional strategies?
- Which one of these instructional strategies do you like better?

In many cases, participants' discussion led them to provide answers to planned prompts that the researchers had not yet asked. In these cases, the researcher briefly asked if participants had any further responses. If participants had no further questions or comments, researchers moved on to the next prompt. Once all prompts had been completed, researchers asked the participants if they had any further questions or comments that they felt were important to mention. Once any questions and comments were completed, the researchers thanked participants for their time, explained compensation procedures, and dismissed the participants.

Training Methods

Four different types of training were explored in the focus groups. The flip-book was presented as a multi-page bound document for the in-person focus groups or a multi-page PDF document for the virtual focus groups (Figure 2). The in-vehicle demonstration, in-vehicle video, and interactive training were conveyed to participants via brief videos. Each of the training methods is explained in further detail below.

Flip Book. The flip-book was intended as a supplementary quick reference guide, aimed to give a basic overview and understanding of what the system is, how the system works, and when to use the system. Researchers explained the flip-book to participants as follows:

> *"This training type uses a visual aid that could be stored in a glove box or with the owner's manual. The flip chart is a bound booklet used as a quick reference guide to show an overview of adaptive cruise control. This is not meant to be the end-all, be-all reference. If more information is needed, the reader would likely consult the owner's manual or other means of obtaining correct information."*

Figure 2. Page of the Flip-Book Providing System Safety Information

In-Vehicle Demonstration. The in-vehicle demonstration focused on the learner receiving training from an "expert" or someone knowledgeable in the system who can convey correct information in a way that a novice or naive learner should understand. This training could be done at the point of sale, such as at a car dealership, or an expert from the car dealership could go to the learner's house, allowing them to sit in a familiar area to learn about the vehicles' features, capabilities, and other information, as shown in Figure 3.

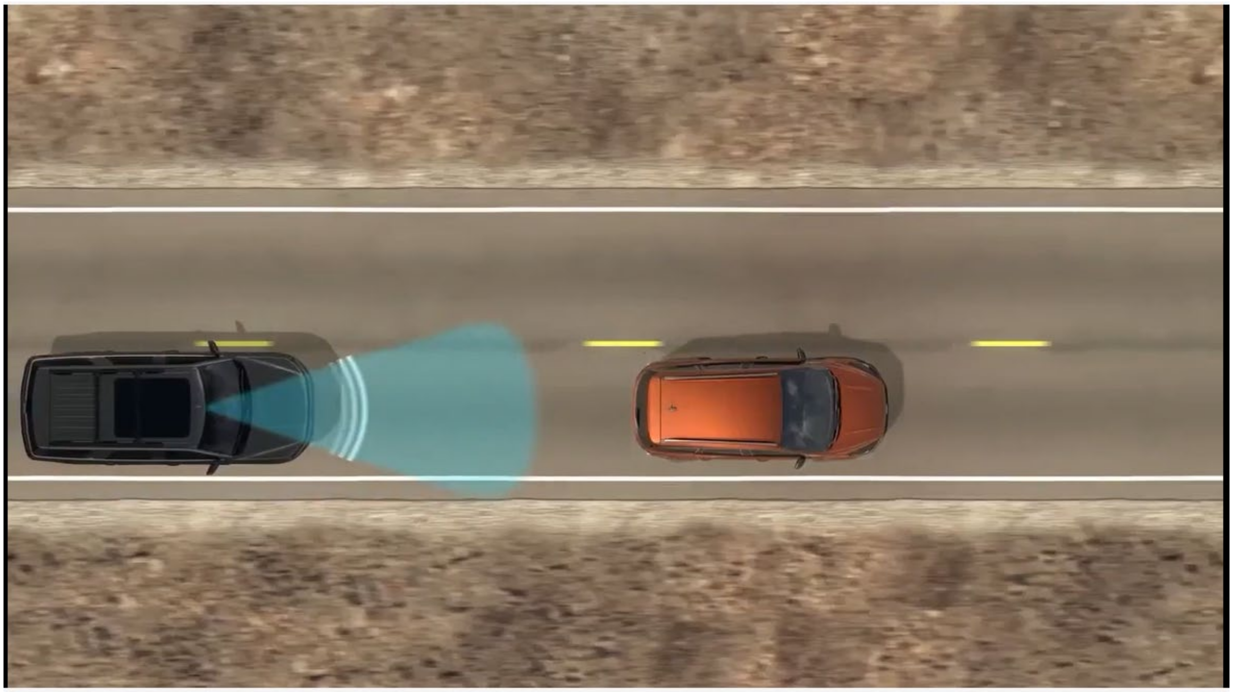
Figure 3. Image from an In-Vehicle Demonstration Video Showing an Expert Pointing Out a System Feature on the Screen of the Vehicle While the New Owner Watches

For the focus groups, researchers explained the in-vehicle demonstration as follows:

> *"The in-vehicle demonstration serves as a training method that would involve using another person with expertise to train a novice user on adaptive cruise control features and operation. This could be used when someone purchases a vehicle from a dealership, which involves a training session. The training session would involve one-on-one training with someone from the dealership where the new vehicle owner sits in the vehicle with an employee then goes for a drive to learn about adaptive cruise control and when to use adaptive cruise control."*

In-Vehicle Video. Researchers modified the length of an existing training video created by an original equipment manufacturer (OEM) as a means of allowing learners to access training in their own vehicle (FordCanada, 2022). No other modifications were made to the video content. The in-vehicle video allows the learner to park their vehicle in a safe area and watch a short video on system capabilities, operation, and use cases while being able to see the buttons or changes in the vehicle as they watch (Figure 4). The videos can be watched multiple times or paused as needed throughout. Each video was designed to share a small subset of information so learners would be less likely to be overwhelmed or frustrated by the amount of information given.

Figure 4. Image from an In-Vehicle Video Explaining how ACC Senses a Vehicle Ahead (Source: FordCanada, 2022)



Researchers described the in-vehicle video to the focus group participants as follows:

> *"The in-vehicle video would show adaptive cruise control features and operations with videos shown on the existing navigation screen of the vehicle. This training method would allow, when parked and in appropriate conditions, drivers to watch a brief video that explains adaptive cruise control, when to use adaptive cruise control, and how to use adaptive cruise control. These videos could be selected and watched at the driver's convenience."*

Interactive Training. The interactive training utilizes the ability for either an artificial intelligence (AI) system or real person to verbally explain vehicle features or other system information to the learner. The research team intended for the interactive training to proactively invite the driver to begin training at a predetermined point, asking the driver if they would like to learn about a feature because they are in an area where the system or feature could be used. Learner responses allow them to begin the training or choose to take the training at a later time, giving them agency in how and when to complete the training. If the learner agreed to complete the training, a voice would walk them through a small section of the system, providing small amounts of information at a time, as shown in Figure 5. Learners could also choose to stop training at any time if they did not wish to continue.

Figure 5. Image from the Interactive Video Demonstration Showing Visual Depiction of the Verbal Response from the System Demonstrating where the ACC Set Speed is Located

Below is the description that researchers used in the focus groups:

"The interactive training would feature the ability for drivers to ask questions in real-time driving situations. When the features are available and appropriate to use, the system will ask the driver if they would like to learn about how and when to use adaptive cruise control. The driver could opt out by saying 'no' or learn more and complete the training by saying 'yes.' If the driver agrees, the system will walk them through the features and how to use [them], where the driver would be able to ask clarifying questions and get more information as needed."

Data Annotation

During the focus groups, researchers utilized the record and transcribe features on Microsoft Teams to collect both .MP3 audio files and Microsoft Word .docx files with transcriptions. Members of the research team then verified accuracy, corrected any inaccuracies, and removed any personally identifiable information from the transcript files. Once this was complete, members of the research team identified excerpts from the transcripts that pertained to the research questions. Each excerpt was then categorized by the focus group number, response number, research prompt used to elicit the response, participant response, and then the three levels of coding as described below.

The three levels of coding consisted of first categorizing responses into one of the four ARCS model categories (Attention, Relevance, Confidence, or Satisfaction). Next, each ARCS model category was further separated into second and third levels of categories and themes that gave context within the ARCS model. Examples of these themes are found below in Tables 4 through 7. Finally, the excerpt was given an attribution of the connotation of the participant's response: positive, negative, or neutral. A response was annotated as "positive" if the participant expressed affirmation, praise, or other attributes indicating constructive outcomes, which would include responses such as, "This is my favorite of the three, easily translatable for those that don't speak English." "Negative" attributes were given to excerpts with disdain, rejection, or general distaste, for example, "It might be distracting." "Neutral" attributes were given to excerpts that had neither positive nor negative connotations, such as, "So I think it has some limitations that the car will tell you."

Next, using Microsoft Excel, researchers created counts of each category and descending theme. These counts were then displayed using Sankey diagrams, shown in Figures 6 through 9. Sankey diagrams are a data visualization tool that displays frequency counts of categories and themes, in each thematic layer, or *flows*. Flows start out at the largest category, in this case the ARCS model categories (Attention, Relevance, Confidence, and Satisfaction) with the frequency count of all codes that fall under that model category. The next flow shows frequency counts of each theme at each ARCS model level. The next level of flows shows the further categorization of each theme, with further frequency counts. The final flow shows the attributes (positive, negative, and neutral) of each theme with the frequency count, if applicable. Due to the nature of participants' responses, there were multiple instances of attribute flows with counts of zero, evident by a missing flow for one or more attributes.

Results

The categories identified in the focus groups are organized following the ARCS model: Attention, Relevance, Confidence, and Satisfaction, with themes identified in the discussion.

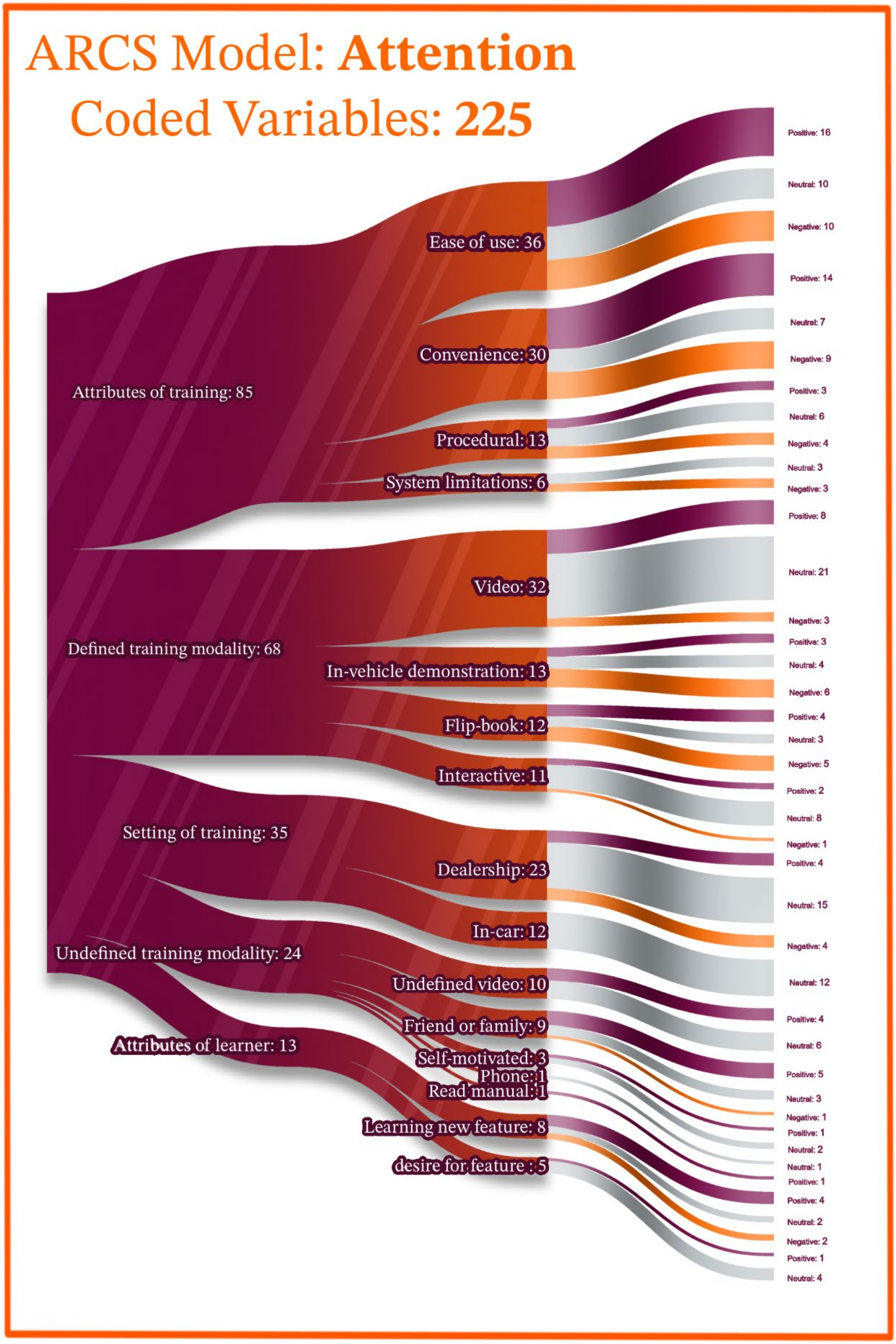
Attention

Excerpts categorized as *Attention* were first coded into categories: attributes of training, defined training modality, setting of training, undefined training modality, and attributes of learner. A total of 225 coded variables were categorized and further stratified into themes. These themes are described in Table 4. As shown in Figure 6, the category *Attributes of Training* was assigned to 85 coded variables that identified aspects of training that may motivate learners to engage or complete training. When asked about motivation for training, a participant said they would like the training to be “Direct and simple.” *Defined Training Modality*, with 68 coded variables, and *Undefined Training Modality*, with 24 coded variables, were excerpts explaining different training mediums categorized by topic origin, whether it was initiated by the researcher (defined) or the participant (undefined). For example, during the discussions after going through the four training types, a participant said, “I think I would prefer to have two, and I would like to have the visual, so I see it when I get in the car, so this is the feature that’s available, and then voice reminder when in a driving situation, it would be applied.” The category *Setting of Training* was used to categorize responses related to the location where the training may take place and contained 35 coded variables. The final category of *Attributes of Learner* identified 13 coded variables where participants identified characteristics of learners that may motivate them to engage with or complete training. Frequency counts of the themes and attributes can be found in Figure 6.

Table 4. List of Category and Theme Coding Variables for the ARCS Model of Attention

Category	Theme	Definition
Attributes of Training	Convenience	The training was engageable when the learner wanted to
	Ease of use	The training was simple to complete
	Procedural	The training explained steps involved
	System limitations	The training explained system limitations
Defined Training Modality	Flip-book	The participant mentioned use of a flip-book for training
	Interactive	The participant mentioned use of an interactive type of training
	Video	The participant mentioned use of an in-vehicle video type of training
	In-vehicle demonstration	The participant mentioned use of an in-vehicle demonstration type of training
Setting of Training	Dealership	The participant mentioned engaging in training at a dealership
	In-Car	The participant mentioned engaging in training in a vehicle
Undefined Training Modality	Friend or Family	The participant mentioned learning from a friend or family member
	Undefined video	The participant mentioned learning from a video
	Self-motivated	The participant mentioned learning from their own internal motivation
	Phone	The participant mentioned learning from their phone
	Read manual	The participant mentioned learning from an owner’s manual
Attributes of Learner	Desire for feature	The learner wanted a feature in their vehicle
	Learning new feature	The learner wanted to understand a new feature

*Figure 6. Sankey Diagram of the 225 Coded ARCS Variables from the **Attention** Category*



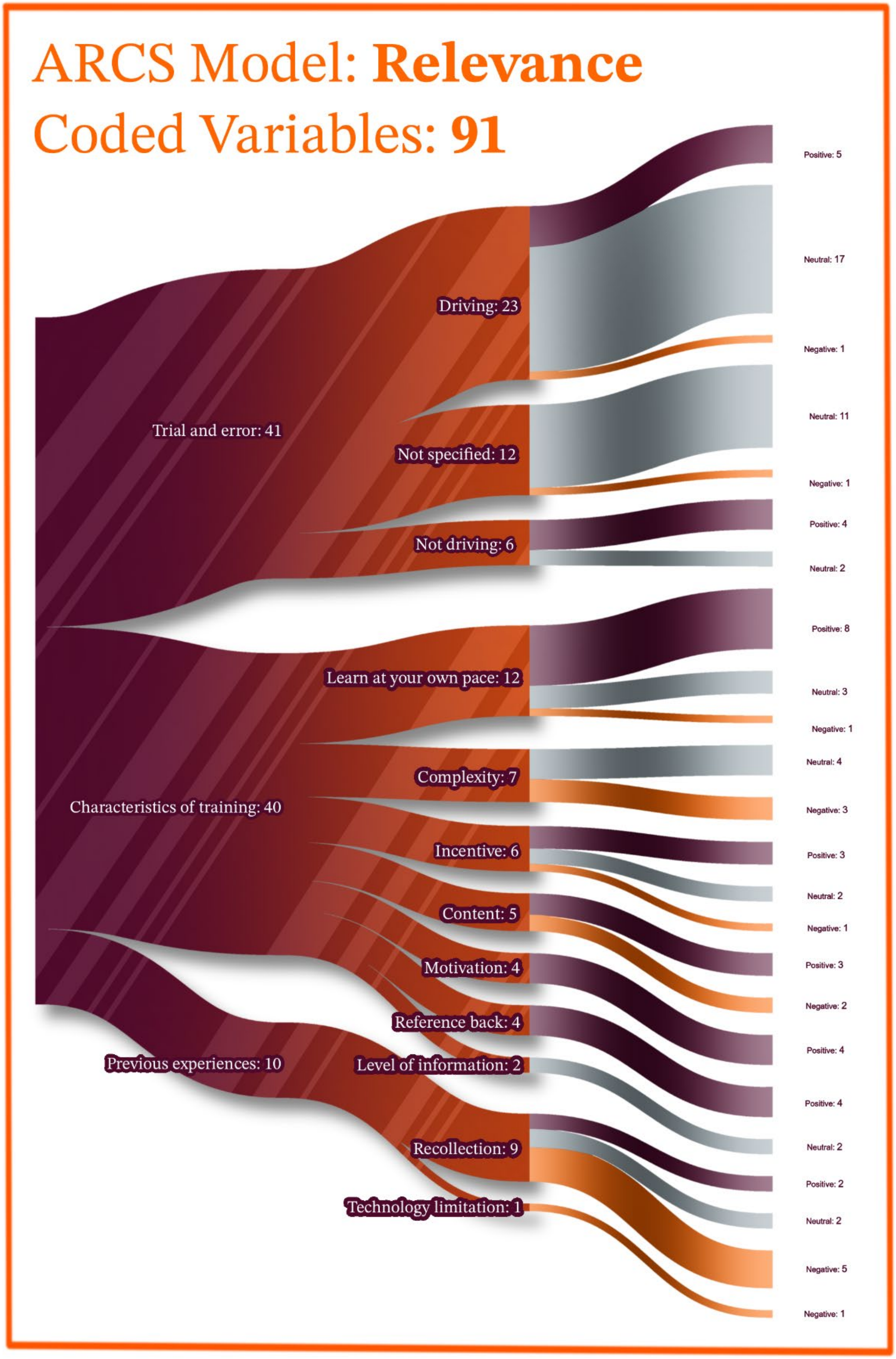
Relevance

A total of 91 coded variables for Relevance were categorized into four categories: characteristics, environment, previous experiences, and trial and error. *Trial and error* was used to categorize 41 coded variables for which participants identified using trial and error to learn features of their vehicle. An example of trial and error is when a participant stated they "put it on and see what happens" when they are using features with which they have no previous experience and implied it with a neutral connotation. *Characteristic*s *of Training* categorized 40 coded variables that gave descriptions of different aspects of the training. When asked about the overall training experience with the flip-book, one participant stated, "Something like this would be helpful too if you do have a rental car for short term then you could understand the features." *Previous experiences* were coded to 10 variables that involved participant recollection of prior uses that informed their desire to engage with training. Further themes and definitions can be found below in Table 5. Frequency counts for themes and attributes are shown in Figure 7.

Table 5. List of Category and Theme Coding Variables for the ARCS Model of Relevance

Category	Theme	Definition
Trial and Error	Driving	Participants mentioned engaging in trial-and-error learning while driving
	Not driving	Participants mentioned engaging in trial-and-error learning while not driving
	Not specified	Participants mentioned engaging in trial-and-error learning but did not specify when
Characteristics of Training	Complexity	Participant mentioned levels of complication with training
	Content	Participant mentioned details of what the training information included
	Incentive	Participant mentioned payment or perks for completing the training
	Learn at your own pace	Participant mentioned completing the training according to their schedule and speed
	Level of information	Participant mentioned varying amounts of information given
	Motivation	Participant mentioned feeling inspired to engage in the training
	Reference back	Participant mentioned repeating training
Previous Experiences	Recollection	Participants mentioned referring to previous experiences
	Technology limitation	Participants mentioned referring to previous experiences in technology limitations

*Figure 7. Sankey Diagram of the 91 Coded ARCS Variables from the **Relevance** Category*



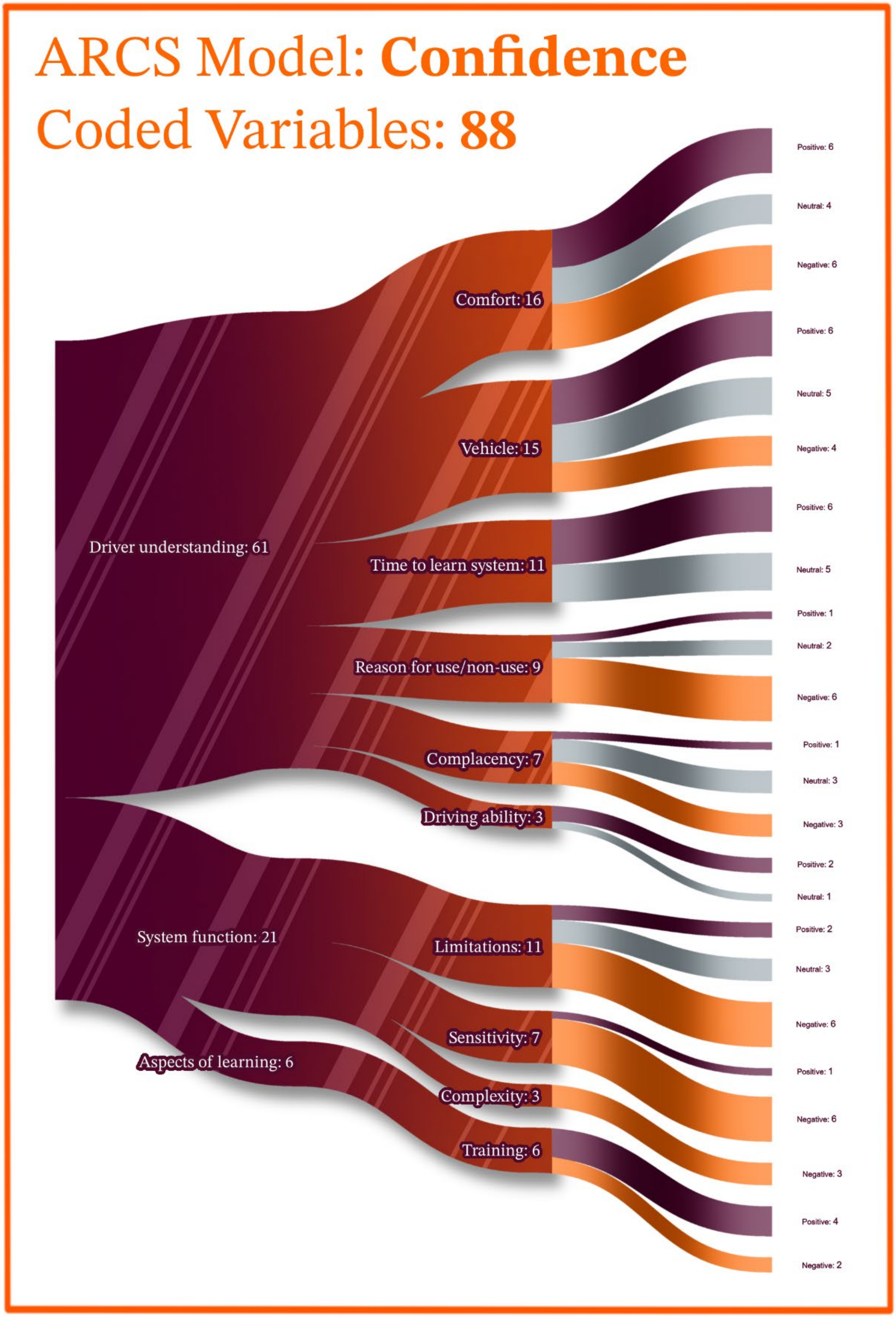
Confidence

Excerpts relating to confidence were categorized into three categories: aspects of learning, driver understanding, and system function, with a total of 88 coded variables, shown in Figure 8. *Driver understanding* encompassed 61 coded variables that involved details that affected the driver's confidence. For example, when participants were asked why they use ACC, one stated, "It's a nice backup. I mean, everybody gets distracted sometimes, and that's a good safety one that's not going to put you in danger." *System function* included 21 coded variables of system operation that affected driver confidence. A participant mentioned system limitation with "oh, it's 70 miles an hour and I'm going 60, but I've set it at 70, but you get in that mode unless you're in autopilot mode. You end up going slower and forgetting that you can pass because you do get so used to it." A participant also expressed concern about the sensitivity of the features, saying, "It's a little scary sometimes when all of a sudden it starts slowing down on me with the cars in front." *Aspects of learning* included six coded variables that involved areas of training that aided driver's confidence. Themes for each category above with definitions are found below in Table 6.

Table 6. List of Category and Theme Coding Variables for the ARCS Model of Confidence

Category	Theme	Definition
Driver Understanding	Comfort	Participant mentioned levels of comfort
	Complacency	Participant mentioned levels of comfort and use in terms of the vehicle's systems
	Driving Ability	Participant mentioned their ability to control the vehicle and use the vehicle's systems
	Reason for use/ non-use	Participant mentioned their use or non-use cases
	Time to learn system	Participant mentioned how long it took for drivers to learn about the system
	Vehicle	Participant mentioned their overall understanding of the vehicle
Aspects of Learning	Training	Participant mentioned information about training that affected their confidence
System Function	Complexity	Participant mentioned how complicated the system was
	Limitations	Participant mentioned system capabilities
	Sensitivity	Participant mentioned the system's sensing abilities and reactions to those abilities

*Figure 8. Sankey Diagram of the 88 Coded ARCS Variables from the **Confidence** Category*



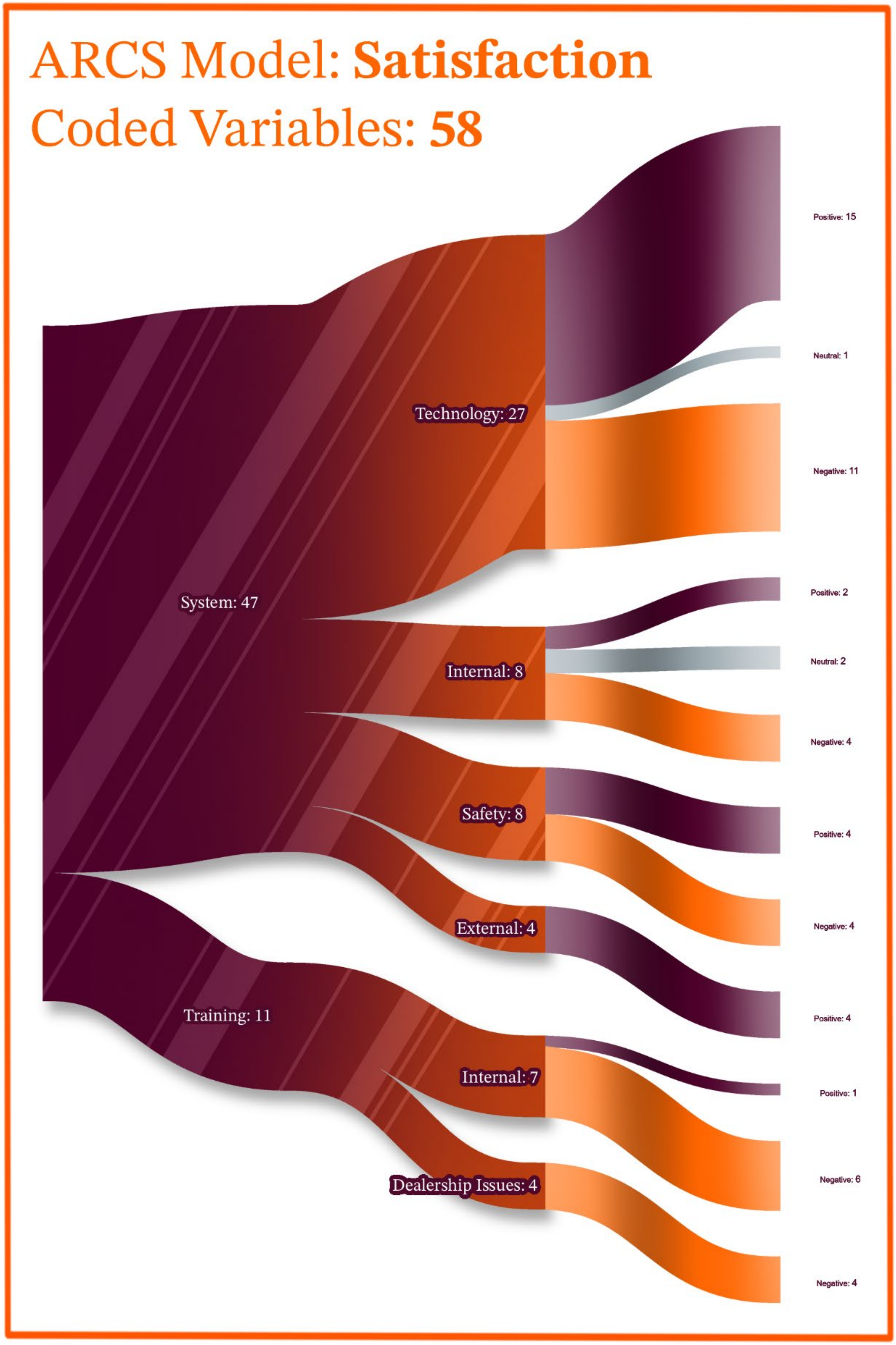
Satisfaction

Satisfaction was categorized into two categories, system and training, containing a total of 58 coded variables. *System* refers to the 47 coded variables of driver fulfillment and enjoyment from the partial driving automation system. When asked about their experiences with ACC, participants said, “I like that it keeps that distance between the vehicles” and “They’re within the distance of how I have it set to be behind the car in front of me. And then all of a sudden there’s a car there and the whole thing, it’ll scream.” *Training* refers to the 11 coded variables of driver’s fulfillment and enjoyment from training for a partial driving automation driving system. With the in-vehicle demonstration, a participant said, “I feel like I would feel nervous and I would much rather find a way to access the information on my own.” The themes for system and training with definitions are shown below in Table 7, with frequency counts for themes and attributes are shown in Figure 9.

Table 7. List of Category and Theme Coding Variables for the ARCS Model of Satisfaction

Category	Theme	Definition
System	Internal	The driver’s emotions or feelings about the system
	External	The driver’s external responses or reactions from the system
	Safety	The driver’s feelings of safety from the system
	Technology	The driver’s feelings of the system features
Training	Dealership issues	The driver’s feelings of the training at the dealership
	Internal	The driver’s emotions or feelings about the training

*Figure 9. Sankey Diagram of the 58 Coded ARCS Variables from the **Satisfaction** Category*



Discussion

Four focus groups were held with drivers experienced with L2 partial driving automation systems to probe their attitudes toward these systems, their process of learning how to use them, general attitudes toward training, and reactions to specific training concepts. Participants' comments were then coded in the context of the ARCS model and themes were identified.

Attention. Within the attention section under the ARCS model, the largest number of coded variables pertained to attributes of training. The largest sub-category, ease of use, contained a plurality of positively coded variables, but contained an almost equal number of negative and neutral coded variables. This suggests that participants believed that ease of use for training is important and instances when the training is not easy to use raise concerns. In cases where the training may be difficult to use, drivers may be less likely to engage with it or complete it, which negates its aim. Following a similar trend, when discussing convenience, a plurality of attributes were positive, though again, a similar number were neutral or negative. Results suggest that training should be convenient for drivers or drivers may not engage due to timing, location, or other factors, which also would reduce use and effectiveness. When structuring training, results suggest that a procedural method is also important. When designing training, it is important to create a workflow and/or system that guides drivers through the process. Training should also convey system limitations to drivers, such as use cases and capabilities, as evident by the negative and neutral attributes for system limitations. Multiple participants identified cases where the system was performing outside of their expectations, which caused negative feelings and responses. By conveying system limitations in training, these interactions may be mitigated, supporting safe driving habits.

After seeing each of the training methods, participants generally supported the use of multiple training types. Specifically, participants expressed fewer negative attributes in association with the in-vehicle video and interactive training, in contrast to the in-vehicle demonstration and flip-book for which more negative attributes were expressed. The in-vehicle demonstration was not widely accepted and was met with a variety of negative responses that affected their trust and desire to engage in the training. Similarly, the flip-book received a variety of negative attributes; however, participants did identify that they would like to use it in conjunction with other forms of training, as a quick reference guide or supplemental training method as opposed to a stand-alone training method. Overall, the in-vehicle video and interactive training appeared to be acceptable methods of training with the flip-book used as a supplemental document.

The training setting was associated with mostly balanced attributes. Participants identified both dealership and in-car training settings with mostly neutral attributes. Dealership training had even but mixed positive and negative attributes, which originated in the convenience of training while at the dealership but included the negative aspect of adding time to an already lengthy and complicated process. In-car training was mentioned with neutral responses as it was a convenient training location but could be affected by the type of training and other factors that may have been coded as other variables, such as in-vehicle video.

Beyond the training methods that were shown to the focus groups, participants also identified other training methods (*undefined* in Figure 6). These included alternative uses of video within the vehicle and the use of friends or family to learn about vehicle systems. The key factor in multiple comments was the ability for drivers to watch within the vehicle so they could see and experience the controls. Participants expressed that it was important to be able to locate and press the buttons, even if the vehicle is not moving, and to learn where menu options were to gain familiarity and comfort in system use. Participants also identified that they would either ask or be shown the system by a trusted relative or friend. Specifically, participants' children and close friends often were identified as the individuals who explained the system.

Attributes of the learner mentioned by participants generally involved the participant's desire to learn about a feature or desire to use a new feature. Participants noted that they would like to learn about updates or new features that become available, especially if they involve vehicle safety. It was also noted that often participants did not know when there were updates to their vehicle or system. They would prefer to know about updates, as well as what benefits are now available. They would also be more likely to engage in training if new updates were better communicated to them.

Relevance. With respect to relevance, participant responses strongly indicated that they rely on trial-and-error learning when first experiencing new technologies. Commonly, participants would either engage and learn new technologies while driving or would sit in their vehicle, while stationary, and learn button locations for turning on a feature or would press buttons to learn what they do. Most of the responses referencing trial and error were classified as positive or neutral—very few were negative—which supports previous research that identified that drivers often learn by trial and error (McDonald et al., 2018; Lubkowski et al., 2021).

Similarly, participants identified multiple criteria involving the characteristics of training. The prevailing opinion was that training should allow drivers to learn at their own pace. Participants felt that this was important to make sure they could understand what is being asked of them, allowing for time to encode the information given. Having the option to pause and restart would help them complete the training. Participants also identified areas of concern if the training was complex, meaning drivers may not engage in training if they feel it is complex. Participants also gave positive attributes to the use of incentives (i.e., insurance discounts, gift cards, etc.) and the ability to refer to the training later, which would help with clarifying any misconceptions after driving the vehicle post-training.

Participants also referenced previous experiences when related to training. Participants often looked back at negative experiences and technology limitations as barriers to training. Thus, it is very important to help drivers understand how technology has advanced and that previous limitations may no longer exist.

Confidence. Participants identified that the driver's understanding may play a critical role in their level of confidence with which they approach training and their expectations of learning. Participants identified that it is important for training to help drivers feel comfortable, allow drivers time to understand the system, and promote and portray system transparency. These factors all impact driver understanding as they are often complementary to one another, where drivers may not understand why the system is behaving as it is, which can affect their comfort and time to learn.

Similarly, participants identified that system functions in terms of sensitivity, limitations, and complexity were important for driver confidence. A large majority of attributes coded for these themes were negative, underscoring the importance of training to convey the limitations, levels of system sensitivity (i.e., gap distance), how to change levels of sensitivity, and limiting system complexity to allow for effective training.

Satisfaction. Participants identified that satisfaction was imperative for system use. Specifically, participants emphasized that the technology itself is key for satisfaction, as shown by polarized attributes. Polarized results align with user expectations of the technology: in some cases, participants indicated satisfaction with how the technology worked to help their driving experience. In other cases, they expressed dissatisfaction when the technology did not behave as expected or desired. Training may help to address this. A few participants seemed to indicate that they were using the technology as if it offered higher levels of automation than they are actually designed to offer, which is concerning with respect to safety. Such misperceptions may also negatively impact satisfaction if system performance does not align with participants' unrealistic expectations. Some participants expressed that the systems made them feel safer, though others expressed the opposite. Aligned with safety concerns, participants' responses also showed concern that the system caused them stress in certain situations, resulting in reluctance to engage the system. Stress was often due to the system behaving outside of the driver's comfort, for example, the system maintaining a smaller gap than the driver would prefer when driving near large trucks or braking with greater force than was expected. However, drivers also indicated that it did make them feel safer, as it would keep them at the posted speed or helped reduce their cognitive load during long drives.

Some aspects of training led to negative participant responses, such as hesitation in using systems if they had not engaged in training or if the training was not aligned with their expectations. Participants also identified training issues stemming from duration and other complications they had experienced at the dealership. Dealerships often came up in conversation with mixed responses; some felt the training at dealerships was positive, while others questioned the quality or overall effectiveness of the training provided at dealerships.

Limitations

While the focus groups yielded many useful insights regarding drivers' learning to use L2 partial driving automation systems, general attitudes toward training, and reactions to specific training concepts, several limitations should be noted. Although participants were required to own vehicles equipped with L2 partial driving automation systems and have experience using the systems, it was evident that some of the participants had poor understanding of the systems, e.g., demonstrating confusion between lane keeping assistance versus lane centering, or expressing that they treated the system as a higher level of automation than it really offers (e.g., expressing that the vehicle was driving for them or that they thought that they could remove their attention from the road). In some cases, this led participants to express negative attitudes toward the systems for not performing in line with their unrealistic expectations. This is not a major limitation for the current study, however, as the current study seeks to gain insight into drivers' attitudes toward the training more than the systems themselves.

Participants were recruited from two geographic locations, which gave a variety of driver experiences on different road types. One region had many limited access highways with lower traffic density in less populated areas, while the other was much more densely populated and featured more traffic congestion. These differences allowed for varying experiences but also required half of the focus groups to take place over teleconferencing software while the other half were in person, which at times may have limited participant engagement with the virtual focus groups. This did not appear to be a major issue; however, it did allow some participants to limit their engagement.

When coding variables, instead of separating responses into multiple shorter responses, each variable was only coded once, meaning depending on the excerpt, it would fall under only one of the four ARCS model categories. Due to the coding protocol, some responses, which may have included content spanning multiple categories, were coded under only the single category that the researchers deemed most appropriate depending on the context. Future work may benefit from an analysis that looks at all comments involving training methods to produce aggregates of overall attributes outside the specific context of the ARCS model. This may help give greater insight into participant opinions about training for vehicle technology in general, including in areas that do not clearly fall into one of the four categories defined by the ARCS model.

Conclusion

The four focus groups provided valuable insights on how drivers learn about new technologies and what training modalities they thought would be most motivating. Participants preferred the idea of an in-vehicle video or interactive training. They thought the flip-book could potentially be helpful as a supplemental reference but should not be the only training provided. They were not enthusiastic about having someone from a dealership train them in-person.

Chapter 3: On-Road Study

An on-road study was designed using critical themes from the findings of each of the previous phases of the project. The goal of this study was to examine whether and to what extent drivers would engage with various forms of training available to them when driving a new, unfamiliar vehicle and intending to utilize the vehicle's L2 partial driving automation technology.

In an attempt to investigate participants' voluntary engagement with training about L2 partial driving automation systems in the context of a reasonably realistic scenario, the study was advertised as an opportunity to drive a new electric vehicle. When participants reported for the study, they were instructed to drive the research vehicle on a prespecified route and to use the vehicle's L2 partial driving automation system whenever it was safe to do so. Two forms of training were made available to each participant: a flip-book plus either an in-vehicle video that could be watched while parked or interactive training that could be performed while driving. (One of the four training approaches considered in previous project tasks—the live in-person demonstration of the system—was not examined here due to participants' negative reactions to this mode of training in the focus groups described previously in Chapter 2.)

The study protocol was designed to make the availability of these training options conspicuous, but participants were not explicitly instructed to use them. Using this approach, the study addressed the following research questions:

- Research Question 1: Do participants engage in the training that was provided to them?
- Research Question 2: How did the training impact L2 partial driving automation system use and driver behavior with the system?
- Research Question 3: When and under what conditions did/would participants use the training?

Method

Participants

Participants between the ages of 25 and 55 years of age were recruited from the New River Valley area of southwestern Viriginia using an existing VTTI research participant pool as well as online advertisements that inquired about drivers' interest in electric vehicles (EV). Recruitment advertisements focused on interest in EVs, rather than ADAS or training, to avoid recruiting participants highly knowledgeable or enthusiastic about vehicle automation or causing them to feel obligated to engage with the training, as participants' voluntary engagement with the training was itself a key outcome measure of the study. Participants were directed to contact the recruitment team if interested and were screened for eligibility.

Participants were required to have a valid U.S. driver's license. They were also required to have little or no experience using L2 partial driving automation features such as adaptive cruise control with lane centering. Specifically, eligible participants were required to have not used L2 features more than three times in their current vehicle or any other vehicle they had driven (i.e., a friend's vehicle, a rental vehicle, or other temporary usage of a vehicle).

The study included 61 participants, consisting of 30 males and 31 females. Participant ages ranged from 25 to 55 years, with an average age of 40.11 years (SD = 9.17 years). The majority of participants (54) were white and 7 identified as other races. Eighteen participants were high school graduates, 19 had bachelor's degrees, and 23 had additional education beyond bachelor's degrees.

Researchers also asked various questions about each participant's vehicle and technology uses. Specifically, 11 participants reported they had previously driven an EV and 50 reported they had not. Participants also reported their experience with EVs (Figure 10) and how likely they were to want to use an EV (Figure 11). Similarly, participants reported on their experience with various vehicle technologies (Figure 12).

Figure 10. Participants Level of Experience with EVs

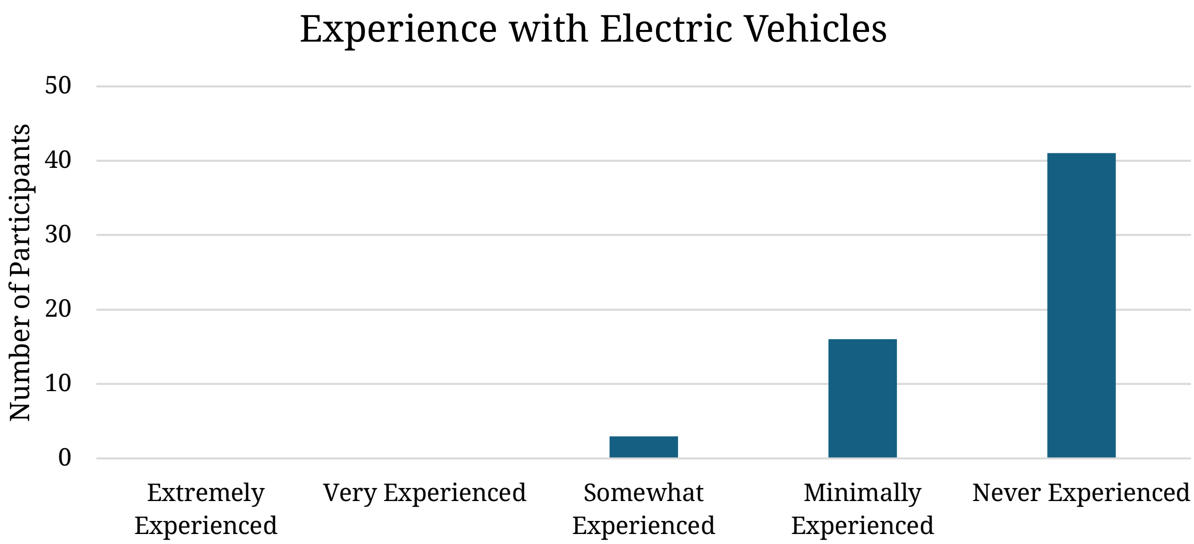


Figure 11. Participants Likelihood of Using an EV

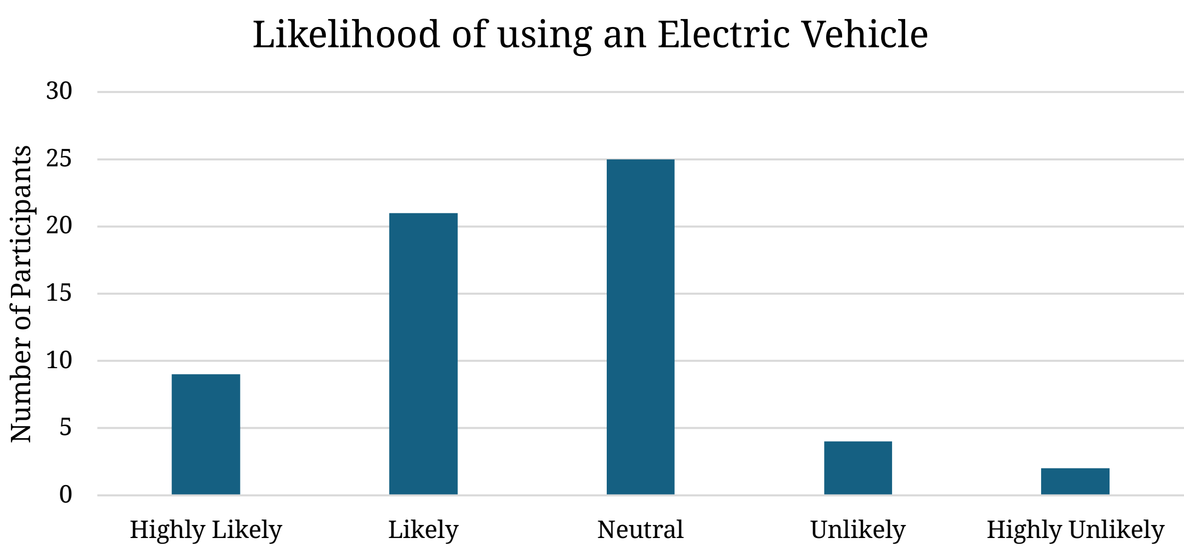
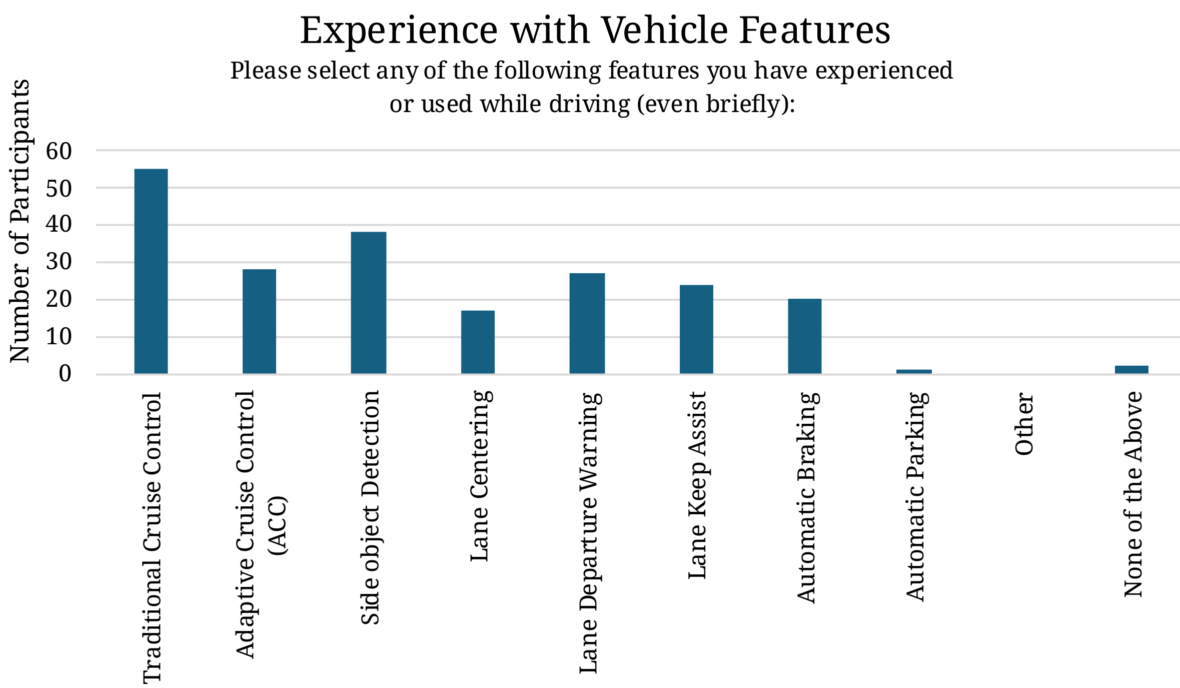


Figure 12. Participant Experience with Vehicle Features



Equipment

The research vehicle was a 2023 Ford Mustang Mach E. The vehicle was equipped with Ford's Co-Pilot360 Driver Assist Technology that consists of assistive technologies such as ACC and LC. The system is not geofenced and requires the driver's hands to be on the steering wheel while the system is in use. In the event that the driver removed their hands from the steering wheel, the system prompts them to place their hands on the wheel. If the driver fails to do so, the system deactivates, and the vehicle activates its hazard lights and decelerates to idle speeds. There are three states for the system: "Active" when the system is engaged and in use, "Standby" where the system is available but is not engaged or being used, and "Off." (The vehicle was also equipped with the Ford BlueCruise system, which is designed to allow hands-free operation under certain conditions. For the purpose of the current study, the research team disabled BlueCruise.)

All Ford branding on the vehicle was obscured, and the vehicle was described to participants as a prototype that VTTI was evaluating. In service to the deception that the vehicle was a prototype, the vehicle's L2 partial driving automation system (Co-Pilot360) was described to participants as an experimental feature and was referred to in all training materials using the fictitious name *Driver Automated In-vehicle System Experience (DAISE)*.

The research vehicle was equipped with a VTTI-developed data acquisition system (DAS) that collected vehicle data, such as GPS location, vehicle speed, and continuous audio and video recordings over the course of the trip (Figure 13).

A tablet was installed in the vehicle (Figure 14) to implement the in-vehicle video and interactive in-vehicle training (described subsequently). The tablet was physically mounted in the vehicle as if it were a static and permanent fixture. This was intended to give participants the impression that the training was being delivered through the vehicle system rather than a mobile device. The DAS also collected data from the tablet to monitor training completion and participant engagement with the training.

Figure 13. DAS Located in the Trunk of the Research Vehicle

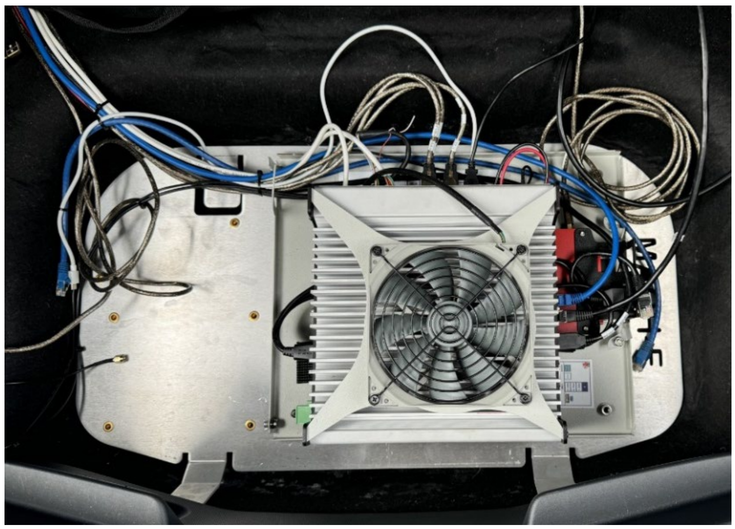
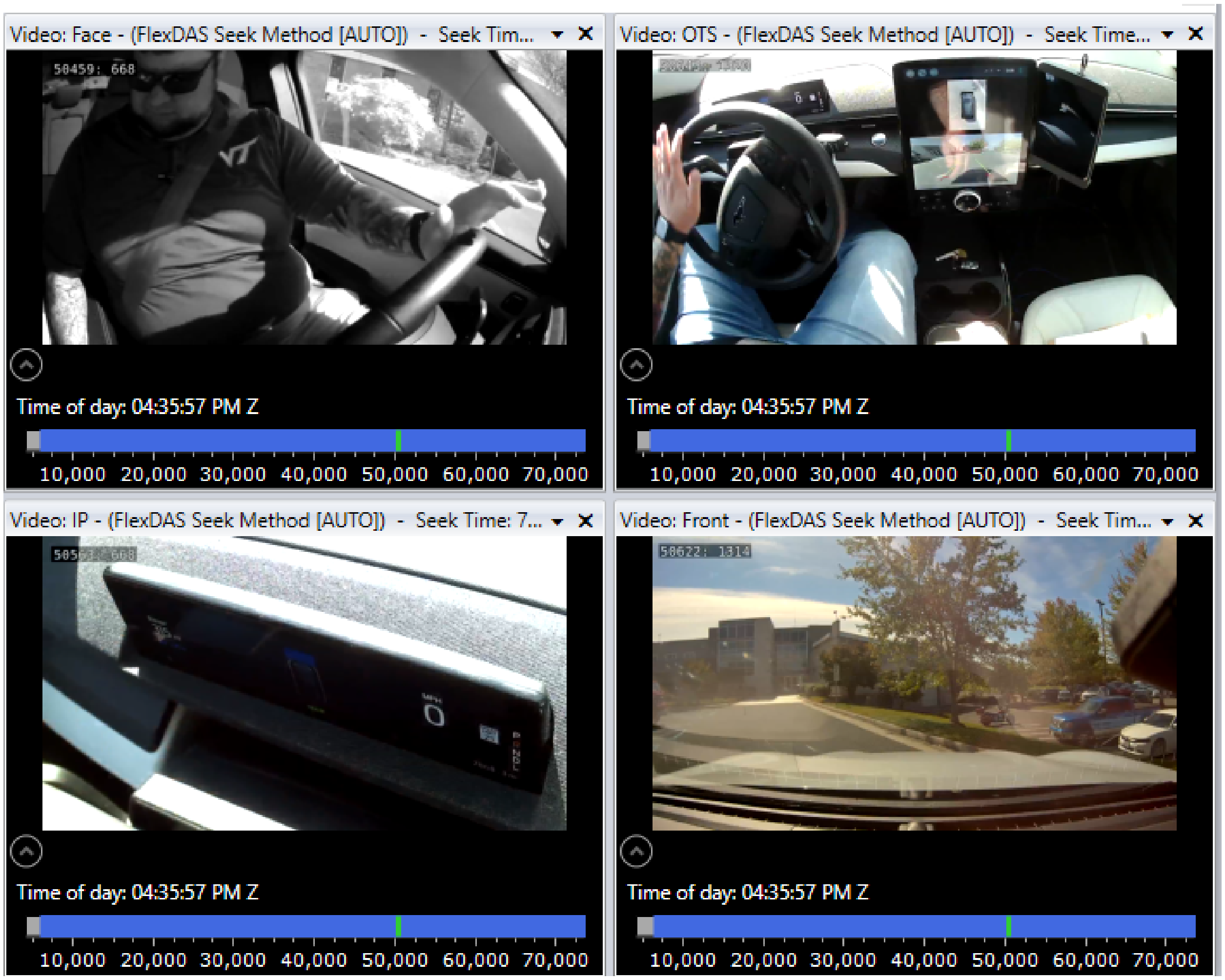


Figure 14. Location of Installed Tablet, Attached to the Right of the Vehicle's Existing Infotainment Screen

Four cameras installed in the vehicle (Figure 15) provided four different views of the interior and exterior of the vehicle. The interior face camera provided a view of the participant's face in order to track where the participant was looking at any given moment. The over-the-shoulder camera provided a view of the participant interactions with the research tablet and infotainment screen on the center stack of the vehicle. The instrument cluster view showed vehicle speed, L2 system status, battery charge level, and other vehicle information. The front camera showed a view of the forward roadway, which provided information about traffic density and other environmental characteristics (e.g., weather). Examples of the four camera views are shown in Figure 16.

Figure 15. Camera Locations (clockwise from the upper left): Participant's Face, Over the Shoulder, Forward View, and Instrument Cluster

Figure 16. Example of the Four Camera Views Collected Using the DAS (clockwise from the upper left): Participant's Face, Over the Shoulder, Forward View, and Instrument Cluster



The vehicle was also equipped with the open-source Comma AI system to collect vehicle Controller Area Network data, such as vehicle speed, L2 system status, and other vehicle information used for analysis. Coupling Comma AI and the VTTI-installed DAS allowed researchers to monitor participant driving progress, as well as L2 system activation before and after training was completed.

Experimental Design

The study employed a between-subject design with 61 participants in an on-road driving experiment. Thirty participants were provided access to an in-vehicle training video, and 31 participants were provided access to interactive in-vehicle training. All participants also had access to a flip-book. Participants were informed that the study aimed to evaluate an electric vehicle and its features; the focus on engagement with training about an L2 partial driving automation feature was not disclosed to participants until after the trial.

Training Types

The purpose of the training was to educate drivers on the use of the L2 partial driving automation technology in the research vehicle (actually Ford's Co-Pilot360), which participants were told was an experimental feature called Driver Automated In-vehicle System Experience (DAISE).

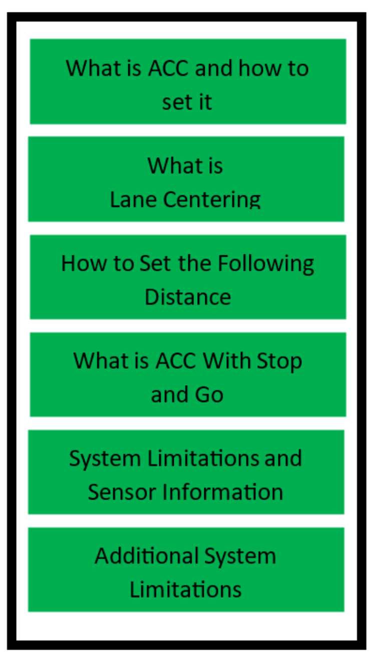
As noted previously, participants were assigned at random to receive access to either an in-vehicle video or in-vehicle interactive training, and all participants also had access to a flip-book. Each of these training types delivered congruent information and, to the extent applicable given differences in mode, approximately equal lengths. Overall, the video and interactive training both delivered approximately 3 minutes of content. Each training type explained the L2 system in terms of what ACC is, what LC is, how to use these features, what the vehicle displays to drivers when these systems are enabled, technical information about the systems, and system limitations. The information provided in all three training types was nearly identical and is shown in Appendix 1.

In-Vehicle Video. The in-vehicle video training consisted of a brief video shown on the tablet in the research vehicle. The video was produced by the Ford Motor Company and available via YouTube (FordCanada, 2022) but was modified by the research team and gave explanations of how and when to use "DAISE" and other relevant system details, such as button locations on the steering wheel (Figure 17). The video was only available to watch when the vehicle was safely parked (i.e., vehicle was stationary with the transmission in the park position). If the vehicle was shifted out of park, the video immediately stopped playing and the DAISE home screen appeared.

Figure 17. Image from the Video Displaying the Location of the ACC Enabling Button on the Steering Wheel

Interactive In-Vehicle Training. The interactive training was presented to the driver on a tablet mounted to the right of the infotainment screen (see Figure 14). An example of the content delivered on the tablet is shown in Figure 18. The tablet was mounted such that it could deliver images without requiring extensive eyes-off-road time by the driver. A flow chart showing all available actions can be found in Appendix 3. The tablet served as a human-machine interface (HMI) where participants controlled their engagement with the interactive training. At predetermined GPS coordinates located on the driving route, an auditory prompt would inform drivers that this might be a good time to learn about "DAISE." Coordinates were selected to ensure that training would only be initiated at locations with uncomplicated driving environments (e.g., straight stretches of road with no merging traffic), and were selected to be approximately evenly spaced. Drivers were then instructed to press a large button on the touch screen to indicate "1. Yes, I would like to learn more" or "2. No, not now." If they pressed yes, the first auditory/visual message would play followed by the topic of the next message. Drivers could then again hit the touch screen to "1. Play next message" or "2. No not now." If at any time the drivers chose "No, not now," a secondary screen would appear that would allow the drivers to hit "Play next message" or "No not now." If they did not hit "Play next message," there were five more GPS coordinates where the system would automatically prompt the drivers to learn more about the system, with the same options as described above (see Appendix 3 for exact location of all GPS coordinates along the route). Drivers could select to engage in the training, delay the training at that time (e.g., if they were in heavy traffic and did not want to be disturbed), or not engage in the training at all. The interactive training consisted of a series of six short audio clips and images, ranging from 15 to about 60 seconds. Appendix 3 contains the script for each clip. If participants chose to engage in the training, a voice gave directions through an external speaker and any associated icons, if used, appeared on the tablet.

Figure 18. Content Shown on the Tablet After Participants Completed the Interactive Vehicle Training



Flip-book. A flip-book accompanied each training type and provided a basic overview of how and when to use the L2 system and other quick reference material. The flip-book was a three-page spiral bound booklet (i.e., printed front and back) that separated ACC and LC information on each page. This was intended to be a quick reference guide for participants to engage with before driving and using the system, but not while the participant was driving. The flip-book was located on the front passenger seat when participants entered the vehicle. Images of the flip-book are provided in Appendix 2.

Procedure

The study involved a single session of 3 to 4 hours comprising three main phases. The first phase was prior to the drive where participants completed introductory paperwork including signing the VT IRB approved informed consent form (IRB # 24-692), a self-report questionnaire, and an introduction to the research vehicle. The second phase was the on-road driving trial, which involved participants driving a predetermined route to and from a waypoint, with a short break at the turnaround location. The third phase was post-drive and included a series of questionnaires the driver completed upon return to VTTI, as well as a semi-structured interview where the researcher asked any relevant follow-up questions. Upon completion of all three phases, the participant was compensated for their time and dismissed from the study.

Pre-Drive. Upon arrival at VTTI, a researcher greeted the participant, and both headed to a private room to complete the consent documents. Participants underwent a basic vision test that matched requirements for operating a vehicle in the State of Virginia (i.e., greater than 20/40 vision) and a short hearing test to confirm they were able to understand and repeat verbal directions. Upon passing the vision and hearing tests, the researcher administered a series of short self-report questionnaires where participants reported demographic information, driving experiences, and vehicle technology experiences. The participant then accompanied the researcher out to the study vehicle.

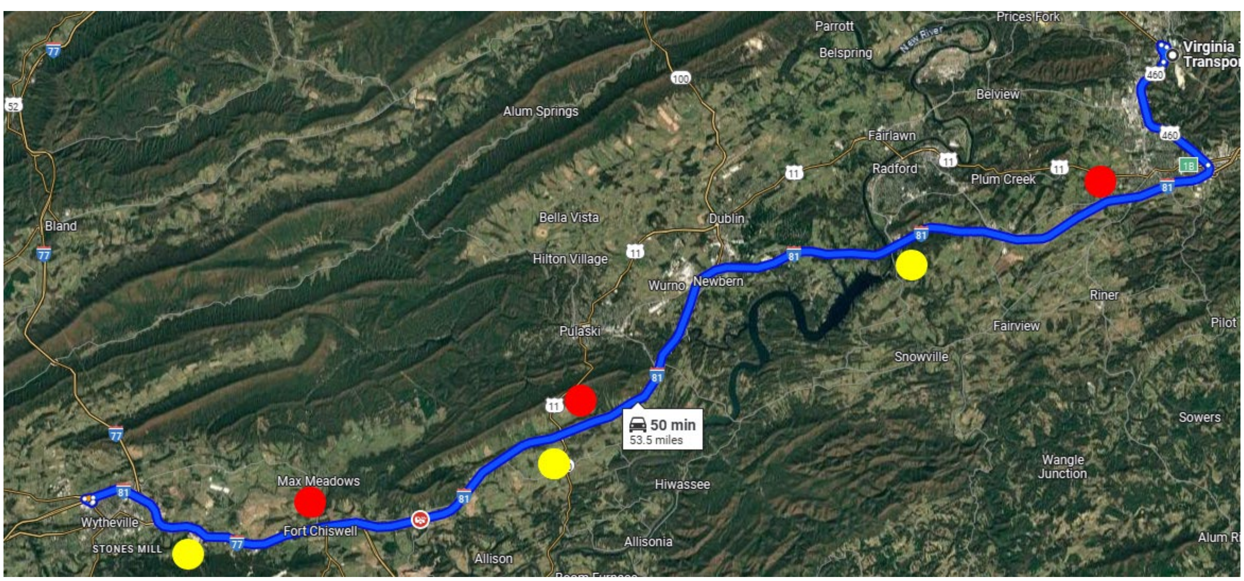
On-Road Driving. To begin, researchers briefed participants on basic vehicle information, including an overview on controls to adjust the seat, steering wheel, and mirrors. Due to participants' inexperience with EVs, they were instructed on how to start the vehicle using the "ignition button," and the researcher explained that because the vehicle lacks an internal combustion engine, it does not produce the traditional engine start-up or idling sounds. Various other elements of interest were described, such as the instrument cluster display, the infotainment screen, and the dial gear shifter, as participants were likely unfamiliar with these features. Once all necessary features of the vehicle were explained, the researcher showed participants how to pair their phone via Bluetooth for hands-free operation and how to program the vehicle's GPS navigation to take them to a designated waypoint and back to the research facility.

Prior to departure, the experimenter requested that the participants use DAISE (the L2 system) while driving the electric vehicle. They were also instructed that they could refer to the training available in their assigned condition (interactive training or video) or the flip-book (located on the front passenger seat when the participant entered the vehicle) if they had any questions about how to use the DAISE system. Participants were not explicitly told to use any of the training options only that they should use the DAISE system while driving.

The participant was also instructed to call the researcher to check-in once they arrived at the waypoint. When they called, they were asked to give an update on the drive and were asked about any adverse weather or events. Participants could also take a break to use the bathroom or get something to eat or drink at this time before setting the vehicle's GPS and returning to the research facility.

Driving Route. The driving route was designed to encompass mostly controlled access highways where L2 systems are designed to operate. Specifically, the route was a 107-mile round trip, with approximately 92 miles on I-81 in Virginia (Figure 19). Participants started at the VTTI research facility. The drive to and from the waypoint generally took approximately 50 to 55 minutes each way, barring any traffic or circumstances that may have increased drive time. The study was conducted between the hours of 9 a.m. and 5 p.m. when no traffic incidents (i.e., road construction, crashes, or backups) or likely adverse weather (i.e., rain, heavy fog, snow, or other adverse conditions) were present. A table of weather events, surface conditions, and traffic densities present during the drives can be found in Appendix 4.

Figure 19. GPS Route followed by the Participants (highlighted in blue)



Red dots above the route indicate the initial drive GPS points where the interactive training prompts were given to participants. Yellow dots below the designated route indicate locations of return drive GPS points.

Post-Drive Questionnaire and Interview

Upon returning to the research facility, the participant was met by a researcher and provided with a series of questionnaires to complete regarding their opinions on the training type they experienced and how useful they felt the training type was. After completing the questionnaires, the participants were asked a short series of questions to gain greater insight into how participants used the training, their likes and dislikes of the training, how they proceeded through the training, and the usefulness of the training. This semi-structured interview format allowed researchers to ask clarifying questions to help elicit responses and gain insight into participants' feelings and experiences.

Data Annotation

Six GPS locations along the driving route, shown in Figure 19 (i.e., three during the drive to the waypoint and three during the return trip to VTTI), were selected prior to data collection activities to achieve consistency in data collection across all participants. As participants crossed each GPS location, the DAS provided a timestamp, in milliseconds, which was used calculate overall driving time between GPS points, as well as the percentage of time the L2 system was active during the trip. The first and fourth GPS points identified the status of the L2 system (i.e., off, ready, active). Additional information related to system status and alerts, such as engagements, disengagements, system warnings, and takeovers was collected for later analysis.

Post hoc data annotation was conducted on instances of training usage while the vehicle was stationary at both the start and waypoint locations. Coders identified if and when participants engaged with the flip-book, watched the video, or interacted with the training module. Participant behaviors, such as attentiveness and completion of the training, were also documented for analysis. Similarly, coders reviewed excerpts of data recorded at each GPS point and annotated driver behaviors, including driving behaviors (e.g., lane changes and speeding) as well as attentional measures related to non-driving tasks (e.g., cell phone, singing). Additionally, coders noted environmental factors such as weather conditions, pavement surface quality, and traffic density.

The interactive training condition required additional annotation to identify the initial use of the training, the number of prompts completed, the number of prompts repeated, the number of times the prompts were delayed, and the attentiveness of the participant to the prompts. Coders began observing participant behaviors 10 seconds before each prompt was given and continued to observe behaviors for 20 seconds after the prompt was completed. In events where participants immediately continued with the next training prompt, coders would continue annotating behaviors until the participant paused between training prompts or all prompts were completed. Prompts played within 30 seconds of each other were grouped into one continuous event.

The post-drive questionnaires were coded using keywords, which were then aggregated and categorized to address the research questions.

Dependent Variables

This study utilized metrics of training usage, L2 system use, and questionnaire data as dependent variables. Table 8 provides details of the dependent variables and the associated levels within these variables. Post-drive questionnaire data consisted of a series of questions to gain insight into participants' thoughts and opinions on the training.

Note that engagement with both the video and the interactive training was measured both by the DAS and by participant self-report in the post-drive questionnaire; however, the only consistently usable measure of engagement with the flip-book was participant self-report. This is because looking at the flip-book could not be recorded by the DAS and participants could potentially look at the flip-book out of view of the video. Thus, analyses of simple engagement with each mode of training are based on self-reported engagement for comparability of results between all modes. However, in-depth analyses of engagement with and attentiveness to the interactive and video modes are based on metrics collected from the DAS and coded by observers from video data.

To evaluate the association of participants' use of the vehicle's L2 system with the type of training provided, the percentage of time that each participant used the system while driving was calculated using the DAS instrumentation. L2 system use was analyzed separately for the initial drive (from VTTI to the waypoint) and the return drive back to the starting point. Amount of time spent driving with the system in standby, or with one of the component systems (ACC or LKA but not both) active and with the system turned off were recorded as well. Driver behavior (e.g., speeding, distraction, drowsiness) was annotated manually by video coders at prespecified GPS locations.

Table 8. Description of Dependent Variables

Variable Type	Dependent Variables	Description	Levels
Training Usage	**Engagement in Training**	Used either of the two training methods available at any point of the trip	Yes/No
	Completion of Training	Was the training completed?	• Video: Yes/No • Interactive: Yes/No and number of training messages played • Flip-book: Yes/No
	Timing of Training	When was the training completed	Before, During, Halfway Point, or End of Trip
	Attentiveness to Training	Did the participant appear to be attentive to the training	Yes/No (N/A for flip-book because flip-book usage was not consistently observable by DAS)
L2 System Use	**Percentage of Trip with L2 System Active**	Amount of time spent on the trip that the participant had L2 system engaged on I-81 between GPS points 1–3 and 4–6	Percentage of time
	Engagement in Secondary Task with L2 System Active	Engaged in a secondary task while L2 system was active/not active	Yes/No, Not Determined, Other, Front Windshield, Cluster, Infotainment, Passenger Side Mirror, Rear View Mirrow, Driver Side Mirror, Driver Side Window, Passenger Side Window, Driver Lap
	Risky Behavior	Engaged in risky driver behavior while L2 system was active/not active	Yes/No, Not Determined, Exceeded Speed Limit, Lane Drifting, Passing on Right, Drowsy Driving
	Number of System-Initiated Disengagements	The number of system-initiated disengagement messages	Frequency Count
Post Drive Interview	**Interview Responses**	• Why did you choose/not choose to engage with the interactive or video training? • When did you interact the training? Why? • Which training would you prefer? • Why would you prefer one? • Would you use any of the training types in something like a rental car situation?	Open-Ended Responses

Results

Research Question 1. Did participants engage in the training that was provided to them?

The majority of participants engaged the training that was made available to their group. Self-reported engagement with the training was greatest among those assigned to the interactive training group, with 87.1% of participants indicating that they engaged with it. Nearly two-thirds of participants assigned to the video training group (63.3%) reported that they viewed the video. All participants also had access to the flip-book, and 55.7% reported that they used it. These differences were statistically significant, $\chi^2(2,58)$, 9.1, $p = 0.011$) (see Table 9).

Table 9. Participant Self-Reported Usage of Training, by Type

	Response		Chi-Square	
Training Type	**Yes**	**No**	**Value**	***p*-value**
Video	19 (63.3%)	11 (36.6%)		
Interactive	27 (87.1%)	4 (12.9%)	9.1	0.011
Flip-book	34 (55.7%)	27 (44.3%)		

Table 10 provides a more detailed breakdown of self-reported training usage, including the use of each mode of training alone as well as in combination. A slightly greater percentage of participants assigned to the interactive training engaged in some form of training (93.5% reported using the interactive training, flip-book, or both) compared to those assigned to the video training (83.3% reported using the video, flip-book, or both); however, this difference was not statistically significant (p=0.21).

Table 10. Self-Reported Participant Responses of Training Use

Training Type	Questionnaire Prompt	Questionnaire Response	Frequency Count	Percentage
Flip-book and Interactive Training	Did you use the flip-book?	Yes	19	61.3%
		No	12	38.7%
	Did you engage with the interactive training?	Yes	27	87.1%
		No	4	12.9%
	Engagement with	Both	17	54.8%
		Neither	2	6.5%
		Only Flip-book	2	6.5%
		Only Interactive	10	32.3%
Flip-book and Video Training	Did you use the flip-book?	Yes	15	50.0%
		No	15	50.0%
	Did you watch the video?	Yes	19	63.3%
		No	11	36.7%
	Engagement with	Both	9	30.0%
		Neither	5	16.7%
		Only Flip-book	6	20.0%
		Only Video	10	33.3%

Engagement with Interactive Training. For the interactive training participants, data coders also reviewed the video from when the participants were receiving interactive training messages. Results showed that 80% of participants assigned to the interactive training group completed most or all of the interactive training, including 74% who completed all of it. Most of them appeared to be attentive to the training.

Six separate interactive training messages were presented. By default, participants were prompted to listen to one training message upon passing each of the six prespecified GPS coordinates, but participants could also opt to initiate training sooner, delay training, or listen to each training message immediately after the previous (i.e., instead of waiting until they reach the next GPS point when they would receive the next prompt automatically). Table 11 shows how many prompts each participant listened to in total. Nearly three quarters of participants (74.2%) listened to all six messages; two (6.5%) engaged with five of the six prompts, one participant (3.2%) engaged with two prompts, and five participants (16.1%) did not engage with any of the prompts. Interestingly, six self-reported having not engaged with the interactive training at all (Table 9), whereas data coders recorded at least some engagement for all but five of the participants.

Table 11. Participant Engagement with Interactive Prompts

Number of Prompts Listened To	Counts	Percentage
6	23	74.2%
5	2	6.5%
4	0	0.0%
3	0	0.0%
2	1	3.2%
1	0	0.0%
0	5	16.1%

As noted previously, participants could wait to be prompted to engage with the training automatically at the prespecified GPS points, but they could also initiate training on their own and/or proceed through it more quickly without waiting for prompts. Table 12 shows how participants chose to pace themselves through the training. Over half of participants who engaged with the training at all progressed through all six training messages consecutively when cued by the system at the first prompt, and another four participants (12.9%) engaged with four or five training messages consecutively at the first GPS point. Only two participants played only one training message at the first GPS point without playing any subsequent messages. Seven participants did not interact with the training at the first GPS point.

Table 12. Number of Prompts Completed by Participants at the First GPS Point

Number of Prompts	Frequency Count	Percentage
All 6	16	51.6%
5	3	9.7%
4	1	3.2%
3	0	0.0%
2	2	6.5%
1	2	6.5%
0	7	22.6%

Throughout the study, participants were able to repeat various prompts. As shown in Table 13, several did so. The highest number of repeated prompts were Prompts 1 and 6, with 32.1% and 21.4%, respectively. Prompt 1 introduces the L2 system, explaining its purpose and how to activate and deactivate the system; Prompt 6 explains the limitations of the system's sensors in poor weather conditions. The contents of all of the prompts are presented in Appendix 3.

Table 13. Participant-initiated Repeats of Prompts During Interactive Training

Prompt Number	Counts of Repeats	Percentage
1	9	32.1%
2	5	17.9%
3	1	3.6%
4	4	14.3%
5	3	10.7%
6	6	21.4%

Data coders also observed and recorded whether each participant appeared to be attentive to the training or whether they appeared to be distracted and/or attending to something else while the training messages were being played. As shown in Table 14, 74% of participants were fully attentive to all of the messages that they played, while 24% did not appear to be attentive to any messages, and 2% (1 person) appeared to be attentive to some but not all of the messages that they played. (Note: in this analysis, instances in which a participant played multiple training messages consecutively were treated as a single “message event” regardless of the number of messages played. Thus, the reported counts sum to the total number of instances of participants listening to training messages, not the number of individual training messages played.)

Table 14. Participant Annotated Attention Levels for Interactive Training

Attention Level	Frequency Count	Percentage
Yes, subject attentive to all messages	40	74.1%
No, subject is not attentive to ANY messages	13	24.1%
No, subject is only attentive to SOME messages	1	1.8%

Research Question 2: How did the training impact L2 partial driving automation system use and driver behavior with the system?

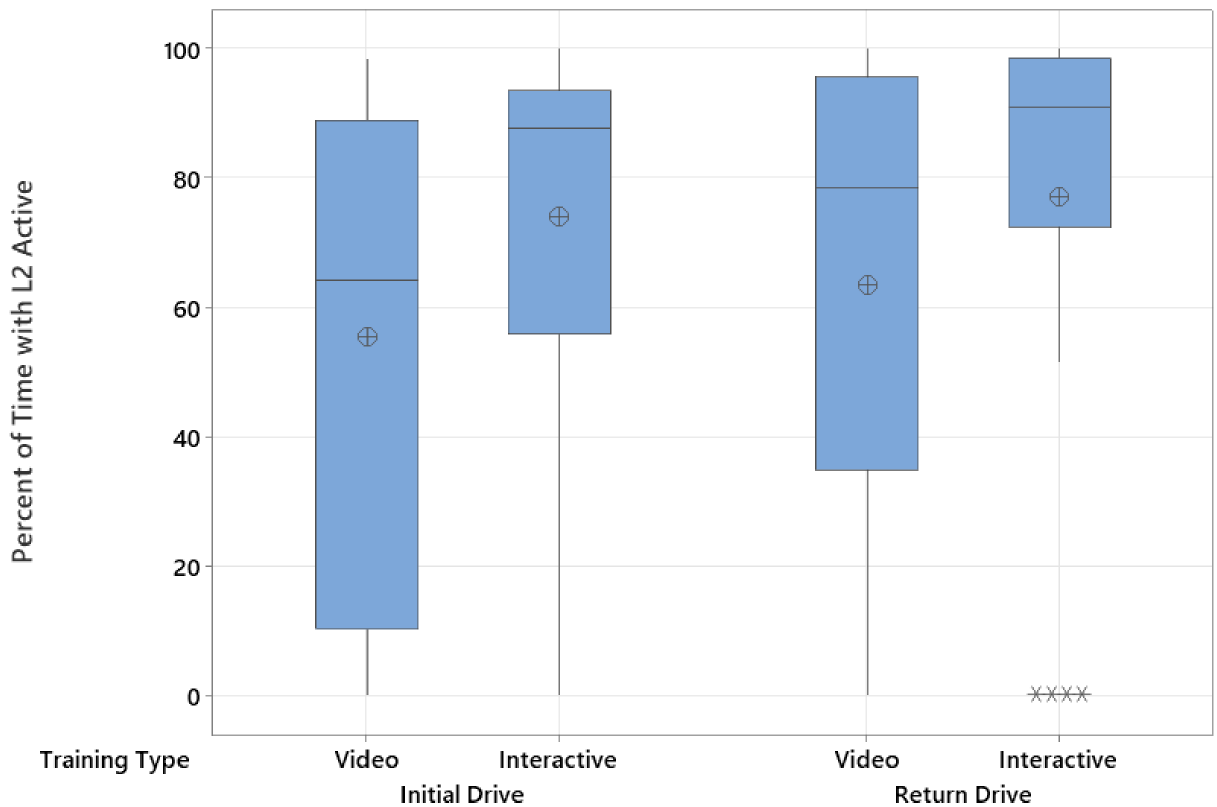
L2 System Use. Overall, participants assigned to the interactive training group used the L2 system for a greater proportion of time than participants assigned to the video training group did. Comparisons of usage during the first half of the drive (to the turn-around point) were statistically significant; though comparisons on the second half of the drive were not (see Table 15).

On the initial drive, participants assigned to the interactive training group used the L2 system for 73.9% of the driving time, whereas participants assigned to the video training group used the L2 system for 55.3% of the time (ANOVA: F: 4.51, p-value: 0.038). On the return drive, those assigned to the interactive training group used the L2 system 77.1% of the time and those assigned to the video training group used it 63.4% of the time, a statistically non-significant difference (ANOVA: *F*: 2.32, *p*-value: 0.133). The distributions of L2 system usage are shown in Figure 20 as a box plot. Additional descriptive statistics are provided in Appendix 4.

Table 15. Overall Percentage of L2 System Active, by Assigned Training Type

Drive	Training Type	*N*	% of Time L2 Active	SD	*F*	*p*-value
Initial Drive	Video	30	55.3%	37.2%	4.51	0.038
	Interactive	31	73.9%	30.8%		
Return Drive	Video	30	63.4%	37.2%	2.32	0.133
	Interactive	31	77.1%	32.5%		

Figure 20. Percentage of Driving Time with L2 System Active in Relation to Assigned Training Type



Note: The upper and lower bounds of the boxes indicate 25th and 75th percentiles, the center horizontal lines indicate the medians, and the circles with connected lines indicate the means.

Despite differences in overall percentage of time spent with the L2 system active, comparisons of the number of participants using the L2 system at specific points along the drive generally were not statistically significant. The status of the L2 system was evaluated at the first GPS point after beginning the drive and the first GPS point encountered on the return trip from the designated waypoint (i.e., point #4); see Table 16. There was no statistically significant difference in the probability of having the L2 system active in relation to training type at either pre-specified location. The only difference that even approached statistical significance was that on the initial drive, more drivers assigned to the video training had the L2 system in standby.

Table 16. L2 System Status in Relation to Training Type as Measured at the First GPS Coordinate for Initial and Return Drives

L2 System Status	Trip Heading	Training Type	Frequency Count	Percentage	Fisher's Test *p*-value
L2 Active	Initial drive	Video	17	57%	1.000
		Interactive	18	58%	
	Return drive	Video	17	57%	0.434
		Interactive	21	68%	
	At least one direction	Video	21	70%	0.570
		Interactive	24	77%	
Standby	Initial drive	Video	4	13%	0.053
		Interactive	0	0%	
	Return drive	Video	3	10%	1.000
		Interactive	3	10%	
Off	Initial drive	Video	9	30%	0.426
		Interactive	13	42%	
	Return drive	Video	10	33%	0.402
		Interactive	7	23%	
	Both drive directions	Video	7	23%	0.762
		Interactive	6	19%	

Using data collected by the in-vehicle DAS, system status was recorded as L2 active (i.e., both ACC and LC active), L1 active (i.e., either ACC or LKA active), or none (neither ACC nor LC/LKA active). Frequency counts for each level of the system by training type and GPS points are shown in Table 17. Among participants assigned to video training, system use remained relatively consistent with minimal change. However, among those assigned to interactive training, L2 system use showed an increase from the first GPS point to the second, with the highest frequency of use observed at the last two GPS points. At each GPS point, several participants had only ACC or LKA but not both active, and a small number with neither system active.

Table 17. Frequency of ADAS Active when Each Participant Reached GPS Points in Relation to Training Type

Training Type	System Active	GPS Point 1	GPS Point 2	GPS Point 3	GPS Point 4	GPS Point 5	GPS Point 6
Video	L2 (both ACC & LC)	21	19	22	20	22	22
	L1 (ACC or LKA)	7	9	6	8	6	6
	None	2	2	2	2	2	2
Interactive	L2 (both ACC & LC)	18	24	26	24	27	27
	L1 (ACC or LKA)	9	5	4	6	3	3
	None	4	1	0	1	1	1

The number of L2 system engagements and disengagements for the initial drive and return drive for both training groups was also examined (Table 18). Overall, there were no noteworthy differences in numbers of system engagements and disengagements in relation to training type. There appeared to be more engagements and disengagements on the initial drive than on the return drive, which may suggest that engagements and disengagements were more frequent as participants were first becoming familiar with the system.

Table 18. Number of L2 Engagement/Disengagements by Training Group and Drive Condition

Training Type	L2 Action	Initial Drive	Return Drive	Totals
Interactive	Engagements	251	190	441
	Disengagements	241	179	420
Video	Engagements	221	183	404
	Disengagements	213	176	389

Driving Behavior. Using the annotated data, participant behaviors were categorized by training type and system usage (Table 19). Overall, the majority of participants exhibited safe driving behaviors with only minimal risky behaviors. Risky behaviors were slightly more frequent among drivers assigned to the video training than among those assigned to the interactive training, though this same general pattern was observed regardless of whether the L2 system was active or not.

While the L2 system was active, the frequencies of observed behaviors such as exceeding the speed limit and drifting within the travel lane was somewhat higher among participants assigned to the video training than among those assigned to the interactive training. A small number of instances of drowsy or fatigued driving were observed among drivers assigned to the video training, though given the nature of the training and study it seems unlikely that this was attributable to the video training.

When driving with only ACC or LKA but not the L2 system active, the majority of participants displayed safe driving behaviors with minimal risky driving behaviors. Risky behaviors such as exceeding the speed limit, passing on the right, and drowsy or fatigued driving were observed among participants assigned to the video training type. Only minimal instances of driving under the speed limit were documented with ACC or LKA active among drivers assigned to the interactive training.

Cases with no driver assistance systems active showed similar behaviors as cases with systems active, with the majority of cases showing safe driving behaviors. Participants assigned to the video training showed cases of lane driving, while the interactive training showed cases of participants exceeding the speed limit.

Further categorization of participant behaviors at each GPS point or interaction with training can be found in Appendix 4.

Table 19. Participant Risky Driving Behaviors Categorized by Training Type

		Video Training		Interactive Training	
L2 Status	Risky Driver Behaviors	Frequency Count	Percent	Frequency Count	Percent
L2 Active	Drowsy, sleepy, asleep, fatigued	4	3.2%	0	0.0%
	Exceeded speed limit	7	5.6%	5	2.9%
	Lane drifting	7	5.6%	5	2.9%
	Passing on right	1	0.8%	1	0.6%
	None	107	84.9%	161	93.6%
	Total events	**126**	**100%**	**172**	**100%**
ACC or LKA Active	Driving below speed limit	0	0.0%	2	5.9%
	Drowsy, sleepy, asleep, fatigued	1	2.3%	0	0.0%
	Exceeded speed limit	7	16.3%	0	0.0%
	Passing on right	1	2.3%	0	0.0%
	None	34	79.1%	32	94.1%
	Total events	**43**	**100%**	**34**	**100%**
No Systems Active	Exceeded speed limit	0	0.0%	2	20.0%
	Lane drifting	4	33.3%	0	0.0%
	None	8	66.7%	8	80.0%
	Total events	**12**	**100%**	**10**	**100%**

Data coders also recorded secondary task engagement (Table 20). When L2 systems were active, center stack adjustments, talking or singing, and tasks involving food and drinks were the most frequently observed secondary tasks, and their prevalence was very similar among participants assigned to the video versus interactive training.

When participants had only the ACC or LKA system active, secondary tasks were more common than when the L2 system was active for drivers assigned to the video condition, but less common than when the L2 system was active for drivers assigned to the interactive training. It is unclear whether this reflects actual differences in behavior when driving with the L2 system active versus inactive or whether this simply reflects differences in the behavior of different drivers who also differed in how much they chose to use the L2 system.

When neither ACC nor LKA was active, only a single case of center stack adjustments and/singing was observed among participants assigned to video training. However, the majority of secondary tasks among participants assigned to interactive training were center stack adjustment.

A full categorization of secondary task engagement at each GPS point or interaction with training can be found in Appendix 4.

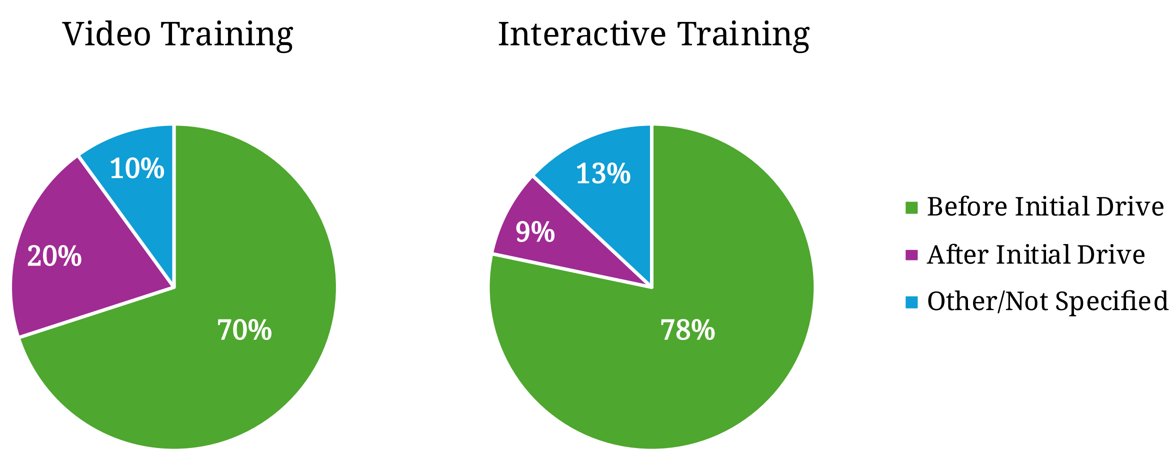
Table 20. Secondary Task Engagement While Driving in Relation to Assigned Training Type and L2 System Status

Status	Secondary Tasks	Video Training		Interactive Training	
		Frequency Count	Total Percentage	Frequency Count	Total Percentage
L2 Active	No secondary tasks	67	45.6%	83	45.9%
	Talking/singing (to self or unknown)	27	18.4%	30	16.6%
	Center stack adjustment	26	17.7%	38	21.0%
	Food/drink	12	8.2%	12	6.6%
	Object in vehicle, other	4	2.7%	1	0.6%
	Dancing	3	2.0%	1	0.6%
	Cell phone visual/manual	2	1.4%	5	2.8%
	External distraction	2	1.4%	3	1.7%
	Integral device adjustment	2	1.4%	3	1.7%
	Other non-specific internal eyeglance	2	1.4 %	2	1.1%
	Personal hygiene	0	0.0%	2	1.1%
	Cell phone talking	0	0.0%	1	0.6%
	Total	**147**	**100%**	**181**	**100%**
ACC or LKA Active	Center stack adjustment	15	27.3%	5	13.5%
	No secondary tasks	14	25.5%	23	62.2%
	Talking/singing (to self or unknown)	13	23.6%	5	13.5%
	External distraction	4	7.3%	0	0.0%
	Food/drink	3	5.5%	1	2.7%
	Dancing	2	3.6%	0	0.0%
	Other electronic device	1	1.8%	0	0.0%
	Other non-specific internal eyeglance	1	1.8%	0	0.0%
	Personal hygiene	1	1.8%	1	2.7%
	Unknown type	1	1.8%	0	0.0%
	Other known secondary task	0	0.0%	1	2.7%
	Cell phone talking	0	0.0%	1	2.7%
	Total	**55**	**100%**	**37**	**100%**
No Systems Active	No secondary tasks	10	83.3%	3	23.1%
	Center stack adjustment	1	8.3%	6	46.2%
	Talking/singing (to self or unknown)	1	8.3%	0	0.0%
	Food/drink	0	0.0%	2	15.4%
	Cell phone visual/manual	0	0.0%	1	7.7%
	External distraction	0	0.0%	1	7.7%
	Total	**12**	**100%**	**13**	**100%**

Research Question 3. When and under what conditions would participants use the training?

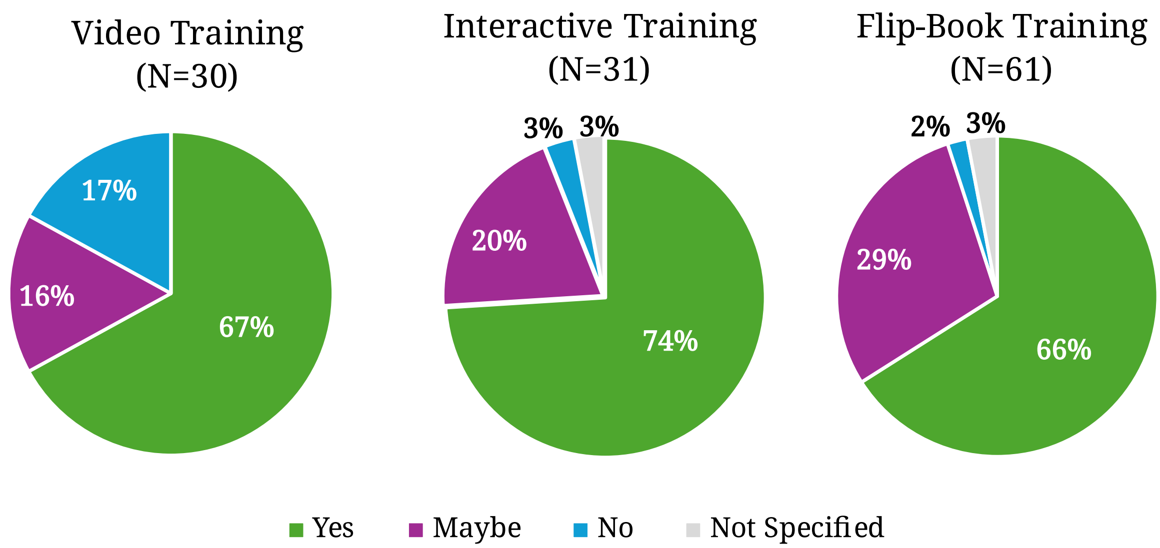
After the drive, researchers interviewed participants to gain insight into their engagement in the different types of training options. Figure 21 shows when participants engaged with the flip-book in relation to their assigned main training type. (Note: participants who did not engage with the flip-book are not included in these figures.) Overall, the majority of the participants who engaged with the flip-book did so before embarking on their drive, regardless of whether the flip-book was paired with the interactive or video training. A small percentage of participants reported engaging with the flip-book after the initial drive (i.e., at the waypoint before their return drive). In addition, a few participants reported engaging with the flip-book at other or unspecified times, suggesting that they might have engaged with the flip-book while driving.

Figure 21. Timing of Participant Engagement with the Flip-Book in Relation to Training Condition (Among Participants Who Reported Engaging with the Flip-Book)



During the post-drive interview, researchers also inquired about participants' opinions of each type of training that they had the opportunity to use in the study, if it were available in the event they were using a new vehicle temporarily, such as when driving a rental car. Responses are shown in Figure 23. For each of the training types examined, the majority of participants who had access to that training in the study stated that they would use it if it were available in a rental car. Specifically, 74% of participants assigned to the interactive training group stated that they would use such interactive training if it were available in a rental car. Similarly, 67% of those assigned to the video training stated that they would use such a video if available in a rental car, and 66% of all participants stated that they would use a flip-book such as that in the study if it were available in a rental car (all participants in the study had access to the flip-book).

Figure *22*. Participants' Intentions to Use Each Training Type if Available in a Rental Car



Note: Base varies because each was asked only of participants assigned that training type in on-road study. (Question: "Would you use the interactive/video/flip-book training in something like a rental car situation?")

Discussion

This on-road instrumented vehicle study used a mixed-subjects approach, where half of the participants were given access to a training video and the other half were given access to interactive in-vehicle training. All participants also had access to a flip-book, which was located on the passenger seat when they entered the vehicle. Participants were not explicitly told to engage with any of the training options made available to them, as their decisions regarding whether to engage with training was itself a main study outcome. A significantly higher percentage of participants reported engaging with the interactive training than the video training. Additionally, a higher percentage of participants who experienced the interactive training expressed that they would use such training in a rental car, compared with the corresponding percentage of participants assigned the video training. A similar percentage of participants who said they would use video also indicated that they would use a flip-book. Collectively, these results suggest that drivers may be more likely to engage with interactive training than with either video-based training or a flip-book. Moreover, the vast majority of participants in the study did engage with at least one of the forms of training available to them in the study, and stated that they would do so in the context of driving a new/unfamiliar vehicle such as a rental car.

The annotated data also provided interesting insight into how participants drove the vehicles given the different types of training they received. There appeared to be less speeding and lane drifting for the interactive training group versus the video training group, particularly when the L2 system was not active. However, neither training mode would have been expected to influence these behaviors, especially while the driver was not using the system that was the subject of the training. Whether these types of training influence driving behavior while using L2 partial driving automation technologies or while not using them could be examined in future research.

Secondary task engagement also differed nominally between the training groups. Apart from the first training prompt for the interactive training group (when these participants often turned the volume down on the center stack) and the fourth prompt, interactions with secondary tasks were less frequent for the interactive training group than the video group. Data coders also evaluated whether the participants seemed to be paying attention to the training messages. A high percentage (74%) of the interactive training participants did seem to be paying attention. These results suggest a possible trend that interactive training participants were able to comprehend the training information better when it was presented to them while actively driving, compared with the video training group who received the training information while the vehicle was parked. In future research, the data collected in the current study could be further coded and analyzed to more comprehensively assess drivers' attention in relation to the types of training provided. Additional data reduction and analysis could also investigate objective measures of engagement with the flip-book as well.

When examining how drivers chose to engage with the interactive training, the data revealed that two-thirds of those who engaged with the training at all proceeded through all six training messages in a row immediately after receiving the first prompt (as opposed to just completing the first training message and then waiting for the system to initiate the next prompt). Focus group participants had indicated that training needed to be self-paced and available. The research team added the ability to listen to the next message, replay messages, and also wait and not play the message until the driver was ready. This control over when the messages are played seemed to improve acceptance, engagement, and willingness to use this type of training in hypothetical future real-world contexts such as when driving a rental car.

The exit interview data indicated not only whether the participants engaged with each type of training, but also whether they would want to use these types of training in the future, for example, when driving a rental car. More than three-quarters of participants in the interactive training group said they would use this type of training if available when driving a rental car, as did two-thirds of those assigned to the video training group. Two-thirds of participants said that they would like to see a flip-book available in a rental vehicle as well. Minimally, 67% of participants indicated that they would use some form of training in such a situation, suggesting that training is desired by a majority of the participants.

Overall, these results tentatively suggest that interactive training may be the best option for developing training that drivers would actually *use*, both in the context of their own personal vehicle as well as when driving an unfamiliar vehicle such as a rental vehicle. Results from the on-road study, as well as previous project tasks, suggest that the ability to access the training at appropriate times, and for it to be self-paced, are important design considerations for training that drivers will actually use.

Finally, it is important to note that while the video and interactive training were implemented using a tablet, the tablet was physically mounted in the vehicle as if it were a static and permanent fixture. This was intended to give participants the impression that the training was integrated into the vehicle. This was done for two reasons: to mimic how such training could actually be implemented by an OEM, and to avoid giving participants the perception that training was being delivered on mobile device such as one might carry into a vehicle. The video training only functioned while the car was not moving. The interactive training, while designed to be used while driving, was deployed in the context of a carefully planned route designed by the research team to minimize the likelihood of encountering dense traffic or overly demanding driving conditions, and was designed to begin at a specific point along the route, which the research team selected based on the characteristics of the location and expected traffic conditions. In addition, the training explicitly permitted participants to opt out of the training or to delay it if they felt uncomfortable or unsafe engaging with the training at that time (e.g., due to traffic conditions or the complexity of the driving environment). However, while designed to mimic the type of training that could in theory be offered by an OEM, such training would benefit from the use of sensor fusion, for example using data from GPS, lidar/radar/cameras, vehicle speed, environmental conditions, traffic conditions, proximity to intersections/interchanges, etc., to ensure that interactive training was limited to conditions when it would be safe to use.

Limitations

This research has several limitations that should be noted. The research team aimed to use congruent data collection sessions to ensure consistency of data and participant safety. Inadvertently, some participants did experience minor adverse traffic or weather conditions, which are detailed in Appendix 4. Overall, it is unlikely that the infrequent and minor adverse conditions encountered impacted study results in any meaningful way.

Regarding engagement with training, the interactive training included audio prompts to engage in the training, whereas the video simply had a visual message displayed on the screen inviting the participant to engage with the video. An auditory prompt and a visual prompt are different, and the auditory prompt may be more attention-getting than a visual prompt. Thus, in the current study, any effects of the mode of the prompt (audio versus visual) versus the timing of the prompt (while parked versus while driving) cannot be disentangled. Additional research will be needed to better assess the importance of an auditory prompt versus a visual prompt.

Minor discrepancies were observed between participants' self-reported engagement with the training versus engagement observed using video integrated into the in-vehicle data acquisition system. This poses a limitation insofar as self-report was the only means of assessing engagement with the flip-book, whereas engagement with the video and interactive training left a clear digital record. Some discrepancies may reflect participant confusion regarding terminology (e.g., not understanding the name of each training) or simply remembering incorrectly. In other cases, the appearance of discrepancies might reflect that a participant technically played a video or an interactive message but did not pay attention to it, in which case self-report might arguably provide a truer reflection of actual engagement.

Participants were also under the impression that the aim of the study was to gain insight into drivers' opinions of electric vehicles. The purpose of using this ruse was to avoid causing participants to feel pressured to engage with the training about the L2 partial driving automation system, as participants' voluntary engagement with the training was itself a key outcome measure. Similarly, researchers only briefly mentioned the training, where they explained that they would like participants to use the "DAISE" system during their drive and that they could read over the flip-book, watch a video, or may be given directions during the drive (depending assigned training condition) if they wanted to learn more about it. Nonetheless, this arguably still represents more of a "nudge" than a driver would receive in most real-world contexts.

Due to the nature of the interactive training, participants in that training type may have exhibited behavior that was incongruent to the video training. During the drive, participants were cued to engage with the tablet (i.e., to play or replay a training message, proceed to the next message, or delay training until later). This behavior was coded as the participant interacting with the center stack, which may have influenced the behavioral measures for the interactive training, especially at the first GPS point where participants may have used the center stack to adjust the volume or other interactions before engaging with the training.

Initially, the research team aimed to only recruit participants who had no knowledge of L2 systems and who did not own a vehicle with L2 systems. However, participants responses when asked about the vehicle technologies in their personal vehicles indicated that participants may not know what is available on their vehicle; in particular, confusion between lane keeping assistance versus lane centering was apparent. Participants also responded that their vehicles had L2 partial driving automation features but did not use them. Given these considerations as well as the project timeline, the research team ultimately decided not to exclude participants who may own a vehicle with ACC and/or LC available. Instead, the team attempted to provide clear descriptions of ACC and LC to potential participants, and excluded those who reported having used an L2 partial driving automation system (i.e., driving with both ACC and LC active simultaneously or using a single system with both features) more than three times. The research team is confident that the participant pool was generally naïve to the technology.

Finally, the study examined only a relatively limited set of driving behavior and performance metrics, and found few major differences in driver's behavior and performance in relation to the training. However, the data compiled from the current study provide opportunities for additional analysis. For example, during data collection, there was one section of roadway containing a bridge with minor road construction. Driver behavior when passing this work zone could be examined in detail to gain insight into how or whether training influenced drivers' use of or interaction with the L2 partial driving automation system while approaching and driving past the work zone. Analysis of these additional data was beyond the scope of the current study as this construction was not anticipated when designing the study. Future research could use these data to gain additional insights.

General Discussion

It is clear from previous research that an accurate understanding of ADAS increases the likelihood that drivers will use these systems safely, and that formal training is instrumental in the development of superior understanding. However, most drivers today do not receive formal training on the technology in their vehicle, and while many sources of information about ADAS exist, the limited research on the subject suggests that most drivers do not use them. The purpose of this research was to determine the essential features of training for ADAS that would maximize the likelihood that drivers would actually use the training, with a hypothetical L2 partial driving automation system used as an example.

In order to determine how training about vehicle technology can be designed to engage drivers, the research team not only drew on human factors experts but also experts in disciplines including adult education, instructional design, and technology. The research team incorporated adult learning and motivational theory into the research plan using the ARCS model (Keller, 1987), which suggests that for training to engage adult learners, it must get their attention, it must be relevant to what they are doing, it must improve confidence, and they must be satisfied that the training was worth the effort. This model helped to guide and direct the overall research project across all phases and methods used to answer the research questions.

The first phase was hosting a one-day workshop. The research team invited multidisciplinary experts to gather their opinions and attitudes toward four different types of training about an L2 partial driving automation system. Second, focus groups were conducted using current drivers of vehicles equipped with L2 systems to assess how they learned to use their system after purchasing their vehicle and how they would have liked to learn to use the system. Finally, an on-road instrumented vehicle study was conducted using drivers without experience using L2 systems. These drivers were afforded the opportunity to engage with two types of training, either an in-vehicle video available while stopped or interactive training designed to be used while driving, both supplemented by a paper flip-book with simple high-level information about using the system. This mixed-method approach has provided an interesting and unique path to examine the essential features of training that would maximize drivers' likelihood of using it.

The key information gleaned from our expert symposium is that each type of training posed has certain strengths and weaknesses, and it is important to capitalize on the strengths of each. Key results from the focus groups suggested that in-person demonstrations (e.g., by car dealership personnel) were not desired, nor were they considered to be useful by drivers who already use these systems. These drivers largely learned to use these systems by trial and error, and deemed their key learning environments to be in the vehicle and/or with family and friends. Drivers also want the training to be easy to use, broadly available, self-paced, and to improve the transparency of how the system works. These key components informed the selection and design of the three training methods examined in the on-road study: video, flip-book, and interactive training.

The on-road study explored how drivers without any experience using L2 partial driving automation systems would engage with different types of training, if offered to them. Using the lessons learned from the workshop and the focus groups, both the video and interactive prompts were designed and provided to the participants in a way that was intended to be easy to use, broadly available, self-paced, and improve system transparency. The results suggested that interactive training was the type that most drivers engaged in and were most likely to say that they would be willing to engage with in the future if it were available in a rental car. Future research needs to be conducted to further ascertain comprehension of the training and its impact on drivers' mental models of L2 partial driving automation systems, behavior, performance, and safety.

Takeaways and Future Goals

The results of the current study suggest that (a) well-designed training that takes into account the needs and goals of adult learners can engage drivers and (b) interactive training has promise to engage drivers. However, some important questions remain unanswered. For example, is the auditory prompt that initiated the interactive training the most effective way to capture drivers' attention and get them to engage? Relatedly, would results have been more similar for the video and interactive training if the video training had incorporated an auditory prompt as the interactive training did?

The data collected for this current study could be further explored to better understand whether the interactive training has any unintended consequences, for example potentially being too distracting for some drivers, given that the training is intended to be used while the driver is also responsible for safe operation of the vehicle on the road with other traffic. To ensure participant safety, the study was designed to limit engagement in training to straight stretches of roadway with light traffic. Similarly, the training was designed to allow participants to delay or ignore the training prompts without having to interact with the tablet. Interactions with the touch screen were designed to limit any eyes off road time by placing the tablet in a high mounted location where participants would only need to glance to the right side but not downward away from the road. The icons and display configurations utilized large buttons and large text to allow for quick glances and interactions with the touch screen. Such safeguards would be extremely important to include in a more general-use case. To gain further insight into driver safety behaviors when engaging with interactive training while driving, additional analyses could include exploration of the alerts that drivers received and examination of driver eye-glance behavior while interacting with the system. Finally, an in-depth error analysis of engaging/disengaging L2 partial driving automation system in relation to training type and trip heading (initial drive/return drive) would also allow for a more nuanced understanding of the training and its effects.

This training was focused on a hands-on L2 partial driving automation system. Hands-free systems are becoming more common over time, and this same type of training could be developed and a study conducted for a hands-free system to determine whether an interactive training module would be as beneficial for those systems as they seemed to be in the current study for a hands-on system. It would be particularly interesting to assess activation/deactivation and alerts, as well as driver behavior such as eyes-off-road for different types of training.

Actual learning outcomes, such as improvement in drivers' mental models of the L2 partial driving automation system after training, were outside the scope of the current study, as the focus was on determining the features of training that would maximize the likelihood that drivers would voluntarily engage with it. However, producing measurable improvements in knowledge and performance is necessary for training to be considered successful. Future research should aim to assess whether such training actually leads to improvements in knowledge, performance, and safety.

While the goal of L2 partial driving automation systems is to provide assistance to drivers, transportation safety researchers also hope that it can improve safety for all road users by using a safe systems approach. Drivers will make mistakes, and technology can help to reduce the mistakes that lead to crashes and reduce the severity of crashes that do occur. It is hoped that by developing approaches to training that drivers will actually use, the appropriate use of partial driving automation systems can be encouraged and that unintentional misuse and intentional abuse of such systems can be prevented, so that the full safety benefits that these systems offer will be realized on our nation's roadways.

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Appendix 1. Comparison of Training Types

Message	Interactive	Video	Flip-book
What are ACC and Lane Centering?	"DAISE is a system that will control the car's speed and will keep it between the lane lines. DAISE is similar to cruise control with the addition that if you are following a slower moving car, DAISE will slow your vehicle to match that car's speed. To engage DAISE, press the button on the left side of steering wheel" (Show Steering Wheel (ACC and Lane Centering.JPG). "Recall that DAISE will control the car's speed but also keep it between the lane lines."	"Your vehicle may be equipped with features that can help you maintain a set speed and pre-set distance from the vehicle ahead of you, help keep you centered in your lane and help bring your vehicle to a complete stop."	"DAISE (Driver Automated In-vehicle System Experience) combines the technologies of Adaptive Cruise Control (ACC) and Lane Centering technology." "Adaptive Cruise Control (ACC) is a smarter cruise control. It uses sensor technology to "see" how close you are to the car in front of you to help maintain a safe distance." "Lane centering is a proactive technology that maintains the vehicle in the center of its own lane."
How to set ACC and Lane Center	"Accelerate to your desired speed, then toggle the set button on your steering wheel. (Show Steering Wheel Resume Cancel Button.JPG) Take your foot off the accelerator and adaptive cruise control and lane centering are set. You should see the blue icon (Show System Ready.JPG) that shows DAISE is active. "To turn DAISE off, you can either tap the brake or hit the Resume/Cancel button the left side of the steering wheel." (Show Steering Wheel (Resume Cancel Button.JPG). To re-activate DAISE, simply hit the Resume/Cancel button again." "A vehicle between two green lane markings will show up on the instrument panel. (Show Green Lane Marking.JPG). If the lane markings are gray, the system is not active but available. Press the button again to activate." "DAISE can be switched off by pressing the brake pedal or cancel button. It can be turned back on using the resume button, (Show Steering Wheel (Resume Cancel Button.JPG)."	"Let's explore Adaptive Cruise Control with Stop-and-Go and Lane Centering. Like normal cruise control, you still have the ability to set your cruising speed, but adaptive cruise control also allows you to set a comfortable distance between your vehicle and the vehicle in front of yours. Accelerate to your desired speed, then press this button on your steering wheel. Take your foot off the accelerator and Adaptive Cruise control is set. This icon will appear in your display." "Keep in mind, once you set you can cancel Adaptive cruise control at any time by braking or by pressing the cancel button on the steering wheel. Pressing the resume button will return the vehicle to the previously set speed and gap setting." "An icon will appear in your display. Green means the system is active and applying steering assistance. Gray indicates the system is on but inactive."	"Controls are located on the vehicle's touch screen, with additional setting options on the steering wheel. Activated driving features can be switched off by pressing the: Brake pedal or, Lane centering button or, Cancel/Resume button or, Adaptive Cruise Control button" "Please refer to the vehicles owner's manual for complete instructions for turning DAISE components on and off."

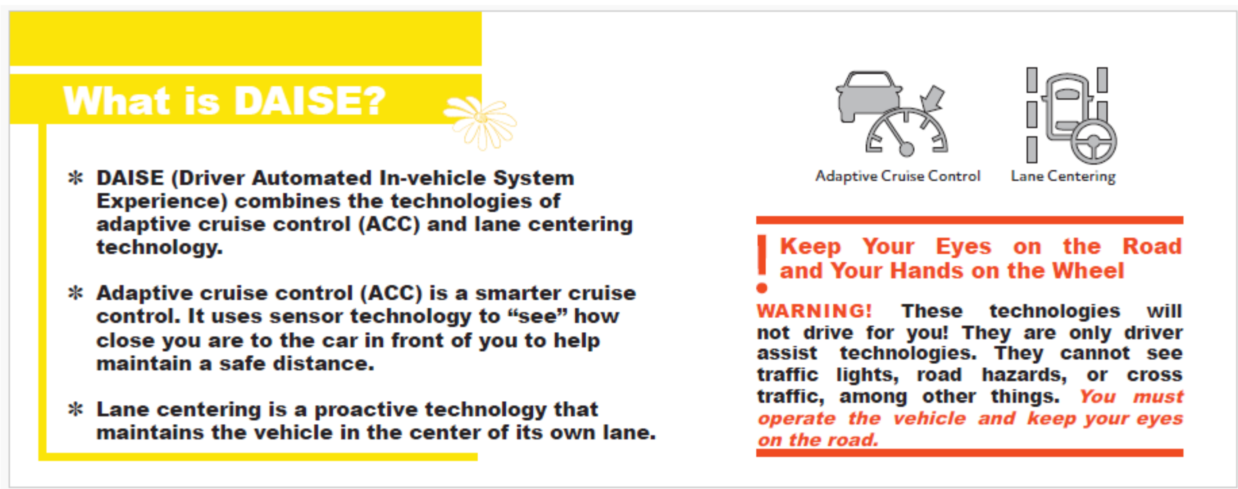
Message	Interactive	Video	Flip-book
ACC and Lane Centering Icons			  Hands-off dashboard alert 

Message	Interactive	Video	Flip-book
Setting the Gap Distance	"DAISE will maintain the speed that you set but if it detects a slower or stopped car in front of you it can help to slow your car down or even bring it to a complete stop." "The vehicle uses radar technology to constantly scan for slower vehicles in front of you and automatically adjust your speed to maintain the gap setting you select." "When following a vehicle, you may use the gap distance button on left side of steering wheel to adjust following distance to the vehicle in front of you." (Show Steering Wheel (Gap Setting Button.JPG). "There are four different gap settings that you can cycle through by continuing to press the gap setting button. Four bars (Show Gap Distance 4 Bars.JPG), which gives you the farthest gap, three bars (Show Gap Distance 3 Bars.JPG), two bars (Show Gap Distance 2 Bars.JPG), and one bar (Show Gap Distance 1 Bar.JPG). Pressing the button again will return your gap setting to four." (Show Gap Distance 4 Bars.JPG)	"To control the distance between your vehicle and the vehicle ahead of you. Press the gap-setting button on your steering wheel. There are four different gap settings that you can cycle through by continuing to press the gap-setting button. Four bars, which gives you the farthest gap, three bars, two bars and one bar. Pressing the button again will return your gap to four."	"Press the gap-setting button on your steering wheel. There are four different gap settings that you can cycle through. By continuing to press the gap-setting button; four bars (which gives you the farthest gap), three bars, two bars, and one bar. At one bar, pressing the button again will return your gap to the four setting."

Message	Interactive	Video	Flip-book
System Limitations & Sensor Information	"DAISE cannot detect obstacles in the roadway, like a piece of tire or other debris. DAISE also cannot see traffic signals and will not stop for a red light. The driver must respond to all traffic control devices and other objects and or obstacles in the roadway. Please remain attentive!" "DAISE uses a combination of forward-looking sensors to detect vehicles in front of you and lane markings. If you can't see the vehicle in front of you because of poor weather conditions, DAISE cannot see it either. Do not use DAISE in poor weather conditions."	"When a vehicle enters the lane ahead of you or a slower vehicle is ahead in the same lane, your vehicle uses radar technology to constantly scar for slower vehicles in front of you, and automatically adjusts your speed to maintain the gap setting you select. You can override the system at any time by applying the breaks yourself." "Lane centering uses radar and sensor to detect painted lane markings and provides continuous steering assistance to help keep your vehicle within its lane while driving. The system must be able to detect both lane markings and you must keep your hand on the steering wheel. Using a hands-on detection method, the system looks for steering input to verify that your hands are on the steering wheel. If you do not react to the warnings, lane centering cancels and slows your vehicle down to idle speeds while maintaining steering control. It will come to a full stop if lane lines disappear."	"Keep Your Eyes on the Road and Your Hands on the Wheel" "WARNING! These technologies will not drive for you! They are only driver assist technologies. They cannot see traffic lights, road hazards, or cross traffic, among other things. You must operate the vehicle and keep your eyes on the road." "When is it NOT safe to use? It does not work when lane markings are faded, obscured or missing. It does not work in heavy rain, fog, or snow. The technology will not work if sensors are covered by ice, snow, or dirt." "DAISE is best suited for: Highway driving Clear weather conditions Roadways with clear lane markings" "Remember: Assistive technologies are only driving aids. Drivers still need to pay attention. Assistive technologies cannot detect all objects. Driver must remain alert. Sensors detect when driver's hands are not on the wheel. Keep hands on the steering wheel while driving in all modes." "When driving, you need to stay alert and pay attention to the road ahead. Drivers still need to pay attention and be ready to brake manually when required."

Message	Interactive	Video	Flip-book
Stop & Go	"When the system brings your car to a complete stop and the traffic in front of you continues to move within 3 seconds your car will automatically accelerate. If you are stopped for more than 3 seconds you will need to either press the resume button (Show Steering Wheel (Resume Cancel Button.JPG) on your steering wheel or press the accelerator pedal to resume acceleration."	"The Stop-and-Go feature comes in handy while driving on the highway in heavy traffic conditions. If the vehicle ahead of you comes to a stop, your vehicle can also follow down to a stop. Once the vehicle ahead begins moving within a short period of about 3 seconds, yours will automatically begin to follow. If the vehicle ahead is stopped for more than 3 seconds, you need to press the resume button on your steering wheel or press the accelerator pedal to resume acceleration."	"This feature is handy while driving on the highway in heavy traffic conditions" "If the vehicle ahead of you comes to a stop, your vehicle can also follow down to a stop." "Once the vehicle ahead begins moving, within a short period of about 3 seconds, yours will automatically begin to follow." "If the vehicle ahead is stopped for more than 3 seconds, you need to press the resume button on your steering wheel or press the accelerator pedal to resume acceleration."

Appendix 2. Flip-book Used in On-Road Study



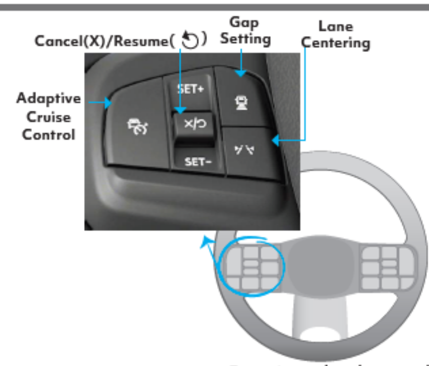
How to Activate

Controls are located on the vehicle's touch screen, with additional setting options on the steering wheel.

Activated driving features can be switched off by pressing the:

- Brake pedal;
- Lane centering button;
- Cancel/Resume button; or
- Adaptive Cruise Control button.

Please refer to the vehicle owner's manual for complete instructions for turning DAISE components on and off.

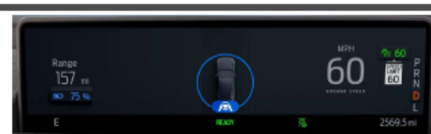


Steering wheel controls

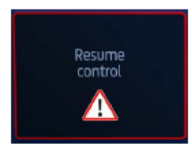
Alerts & Warnings

- ***When driving, you need to stay alert and pay attention to the road ahead.***
- ***Drivers still need to pay attention and be ready to brake manually when required.***

Dashboard with systems active



Dashboard with systems ready but not active



Hands-off dashboard alert

Gap Settings

Press the gap-setting button on your steering wheel. There are four different gap settings that you can cycle through. By continuing to press the gap-setting button; four bars (which gives you the farthest gap), three bars, two bars and one bar. At one bar, pressing the button again will return your gap to the four setting.

Stop and Go

* This feature is handy while driving on the highway in heavy traffic conditions
* If the vehicle ahead of you comes to a stop, your vehicle can also follow down to a stop.
* Once the vehicle ahead begins moving, within a short period of about 3 seconds, yours will automatically begin to follow.
* If the vehicle ahead is stopped for more than 3 seconds, you need to press the resume button on your steering wheel or press the accelerator pedal to resume acceleration.

Appendix 3. Scripts Used for Interactive Training

Intro Prompt: "If you are in comfortable traffic conditions, it would be a good time to learn about DAISE. If you want to learn more now, Press YES button on the DAISE display."

No Prompt: <If driver responds Not Now, changes to second screen with Okay I'm Ready and Not Interested>. "If at any time you want to learn more, press the I'm Ready Now button on DAISE display."<If driver responds yes, screen goes black and the message below plays>.

Final Prompt: "If you would like to go over any of these topics again, press the topic name. You can go over each topic as many times as you like."

Prompt 1: "DAISE is a system that will control the car's speed and will keep it between the lane lines. DAISE is similar to cruise control with the addition that if you are following a slower moving car, DAISE will slow your vehicle to match that car's speed. To engage DAISE, press the button on the left side of steering wheel" (Show Steering Wheel (ACC and Lane Centering Images) **5 Second Pause.** "Accelerate to your desired speed, then toggle the set button on your steering wheel. (Show Steering Wheel Resume Cancel Button Image) Take your foot off the accelerator and adaptive cruise control and lane centering are set. You should see the blue icon (Show System Ready.JPG) that shows DAISE is active. **5 Second Pause** "To turn DAISE off, you can either tap the brake or hit the Resume/Cancel button the left side of the steering wheel." (Show Steering Wheel (Resume Cancel Button Image). To re-activate DAISE, simply hit the Resume/Cancel button again." **5 Second Pause** "Next, we will learn about lane centering. If you would like to learn more, press continue"

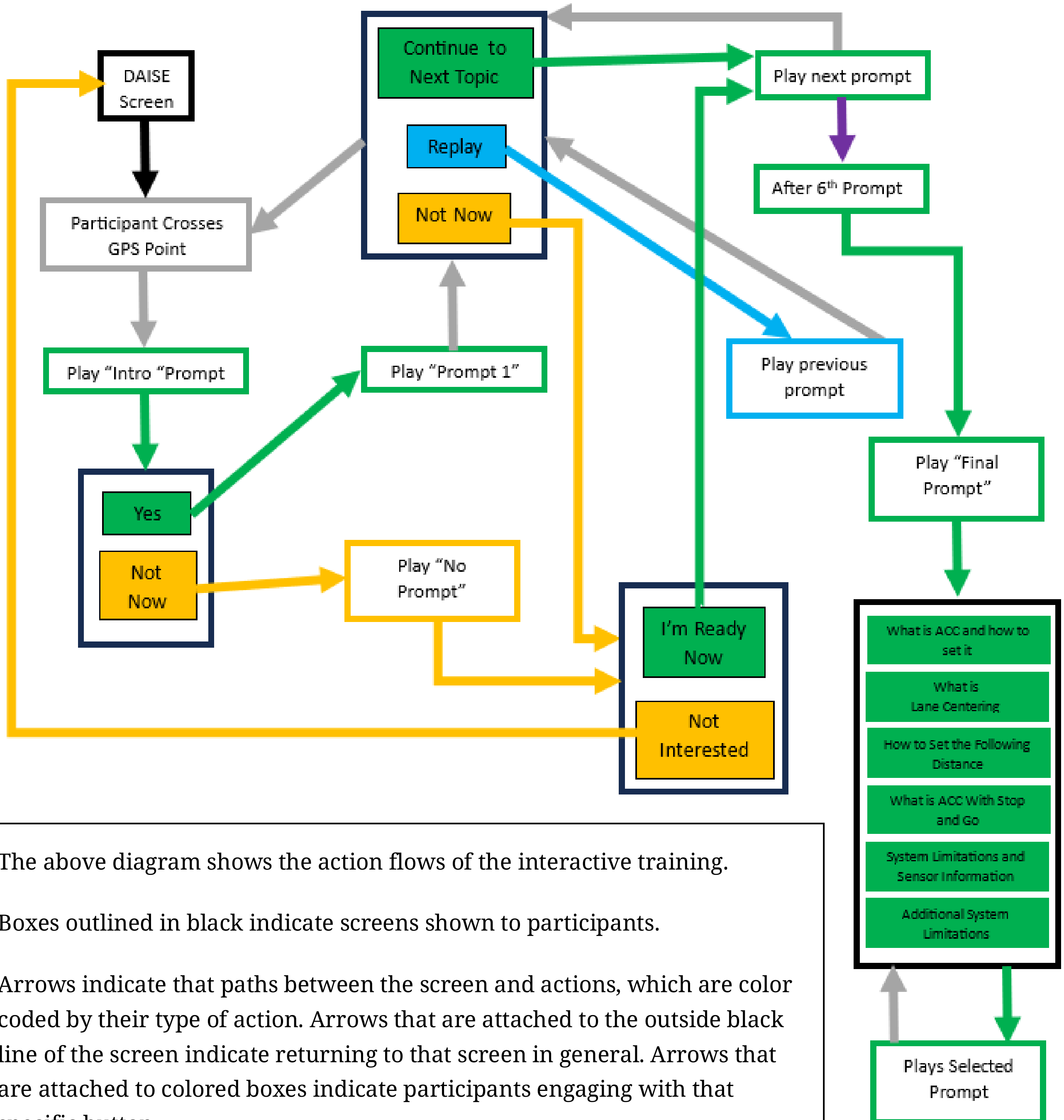
Prompt 2: "Recall that DAISE will control the car's speed but also keep it between the lane lines. A vehicle between two green lane markings will show up on the instrument panel. (Show Green Lane Marking Image). If the lane markings are gray, the system is not active but available. Press the button again to activate." **5 Second Pause** "DAISE can be switched off by pressing the brake pedal or cancel button. It can be turned back on using the resume button, (Show Steering Wheel (Resume Cancel Button Image)." **5 Second Pause** "Next, we will learn about setting the following distance. If you would like to learn more, press continue."

Prompt 3: "DAISE will maintain the speed that you set but if it detects a slower or stopped car in front of you it can help to slow your car down or even bring it to a complete stop." **5 Second Pause** "The vehicle uses radar technology to constantly scan for slower vehicles in front of you and automatically adjust your speed to maintain the gap setting you select." **5 Second Pause** "When following a vehicle, you may use the gap distance button on left side of steering wheel to adjust following distance to the vehicle in front of you." (Show Steering Wheel (Gap Setting Button.JPG)**.** "There are four different gap settings that you can cycle through by continuing to press the gap setting button. Four bars (Show Gap Distance 4 Bars Image), which gives you the farthest gap, three bars (Show Gap Distance 3 Bars. Image), two bars (Show Gap Distance 2 Bars Image), and one bar (Show Gap Distance 1 Bar Image). Pressing the button again will return your gap setting to four." (Show Gap Distance 4 Bars Image), **5 Second Pause** "Next, we will learn more about stop and go traffic capabilities. If you would like to learn more, press continue."

Prompt 4: "When the system brings your car to a complete stop and the traffic in front of you continues to move within 3 seconds your car will automatically accelerate. If you are stopped for more than 3 seconds you will need to either press the resume button (Show Steering Wheel (Resume Cancel Button Image) on your steering wheel or press the accelerator pedal to resume acceleration." **5 Second Pause.** "Next, we will learn about the systems limitations. If you would like to learn more, press continue."

Prompt 5: "DAISE cannot detect obstacles in the roadway, like a piece of tire or other debris. DAISE also cannot see traffic signals and will not stop for a red light. The driver must respond to all traffic control devices and other objects and or obstacles in the roadway. Please remain attentive!" **5 Second Pause** "If you would like to learn additional information about system limitations, press continue."

Prompt 6: "DAISE uses a combination of forward-looking sensors to detect vehicles in front of you and lane markings. If you can't see the vehicle in front of you because of poor weather conditions, DAISE cannot see it either. Do not use DAISE in poor weather conditions."



The above diagram shows the action flows of the interactive training.

Boxes outlined in black indicate screens shown to participants.

Arrows indicate that paths between the screen and actions, which are color coded by their type of action. Arrows that are attached to the outside black line of the screen indicate returning to that screen in general. Arrows that are attached to colored boxes indicate participants engaging with that specific button.

Grey boxes and lines indicate automatic options, such as the vehicle passing a GPS Point, which triggers a prompt or a prompt finishing which automatically causes a new screen to be shown to participants.

Boxes and arrows shown in yellow indicate flows where participants delay or indicate they are not interested in the training.

Appendix 4. Additional Data from On-Road Study

Table A4-1. Use of L2 Partial Driving Automation System by Training Type in On-Road Study

Training Type	Measure	Mean	SD	Median	Min	Max
Interactive	Initial drive percent of time L2 active	73.90	30.79	87.55	0	99.99
	Initial drive number of L2 engagements	8.10	5.21	8	0	20
	Initial drive number of L2 disengagements	7.77	5.06	7	0	19
	Initial drive number of hands-off alerts	29.68	19.28	22	7	83
	Return drive percent of time L2 active	77.06	32.52	90.89	0	99.99
	Return drive number of L2 engagements	6.13	5.54	4	0	19
	Return drive number of L2 disengagements	5.77	5.31	4	0	18
	Return drive number of hands-off alerts	39.77	43.57	25.50	1	191
Video	Initial drive percent time of L2 active	55.30	37.19	64.07	0	98.23
	Initial drive number of L2 engagements	7.37	5.81	7	0	20
	Initial drive number of L2 disengagements	7.10	5.36	7	1	19
	Initial drive number of hands-off alerts	35.10	21.31	31	6	85
	Return drive percent of time L2 active	63.41	37.24	78.44	0	99.99
	Return drive number of L2 engagements	6.10	5.27	5.5	0	19
	Return drive number of L2 disengagements	5.87	5.01	4.5	0	18
	Return drive number of hands-off alerts	50.07	44.17	41.5	3	149

Table A4-2. Secondary Task Frequency by ADAS Activation, Training Type, and GPS Location

	Secondary Tasks	Total Frequency Count	Total Percentage	GPS Point 1	GPS Point 2	GPS Point 3	GPS Point 4	GPS Point 5	GPS Point 6	Non-GPS Point
Video Training Group										
L2 Active	No secondary tasks	67	45.58%	11	12	10	11	11	12	–
	Talking/singing (to self or unknown)	27	18.37%	6	4	5	5	3	4	–
	Center stack adjustment	26	17.69%	4	2	9	3	4	4	–
	Food/drink	12	8.16%	0	1	1	5	2	3	–
	Object in vehicle, other	4	2.72%	0	0	0	0	3	1	–
	Dancing	3	2.04%	0	0	0	1	2	0	–
	Cell phone visual/manual	2	1.36%	0	0	0	1	1	0	–
	External distraction	2	1.36%	1	0	0	0	0	1	–
	Integral device adjustment	2	1.36%	0	0	1	0	0	1	–
	Other non-specific internal eyeglance	2	1.36%	2	0	0	0	0	0	–
	Total	**147**	**100%**	**24**	**19**	**26**	**26**	**26**	**26**	–
L1 Active	Center stack adjustment	15	27.27%	4	3	1	2	2	3	–
	No secondary tasks	14	25.45%	3	2	2	3	2	2	–
	Talking/singing (to self or unknown)	13	23.64%	0	1	4	3	3	2	–
	External distraction	4	7.27%	1	1	0	1	1	0	–
	Food/drink	3	5.45%	1	0	1	0	1	0	–
	Dancing	2	3.64%	0	1	0	0	1	0	–
	Other electronic device	1	1.82%	0	1	0	0	0	0	–
	Other non-specific internal eyeglance	1	1.82%	1	0	0	0	0	0	–
	Personal hygiene	1	1.82%	0	0	0	0	0	1	–
	Unknown type	1	1.82%	0	1	0	0	0	0	–
	Total	**55**	**100%**	**10**	**10**	**8**	**9**	**10**	**8**	–
Inactive	No secondary tasks	10	83.33%	1	2	2	2	2	1	–
	Center stack adjustment	1	8.33%	0	0	0	0	0	1	–
	Talking/singing (to self or unknown)	1	8.33%	1	0	0	0	0	0	–
	Total	**12**	**100%**	**2**	**2**	**2**	**2**	**2**	**2**	–

	Secondary Tasks	Total Frequency Count	Total Percentage	GPS Point 1	2	3	4	5	6	Non-GPS Point
Interactive Training Group										
L2 Active	No secondary tasks	83	45.86%	4	15	12	11	15	13	13
	Center stack adjustment	38	20.99%	9	2	10	4	0	6	7
	Talking/singing (to self or unknown)	30	16.57%	4	6	3	5	4	4	4
	Food/drink	12	6.63%	0	0	0	3	4	4	1
	Cell phone visual/manual	5	2.76%	1	1	0	0	1	2	0
	External distraction	3	1.66%	0	0	0	2	1	0	0
	Integral device adjustment	3	1.66%	0	1	1	0	1	0	0
	Other non-specific internal eyeglance	2	1.10%	0	0	0	0	2	0	0
	Personal hygiene	2	1.10%	1	0	0	0	0	0	1
	Cell phone talking	1	0.55%	0	0	0	0	1	0	0
	Dancing	1	0.55%	0	0	0	0	0	0	1
	Object in vehicle, other	1	0.55%	1	0	0	0	0	0	0
	Total	**181**	**100%**	**20**	**25**	**26**	**25**	**29**	**29**	**27**
L1 Active	No secondary tasks	23	62.16%	5	5	3	3	3	1	3
	Center stack adjustment	5	13.51%	4	0	0	1	0	0	0
	Talking/singing (to self or unknown)	5	13.51%	1	0	1	1	0	1	1
	Cell phone talking	1	2.70%	0	0	0	1	0	0	0
	Food/drink	1	2.70%	0	0	0	1	0	0	0
	Other known secondary task	1	2.70%	0	0	0	0	0	1	0
	Personal hygiene	1	2.70%	0	0	0	1	0	0	0
	Total	**37**	**100%**	**10**	**5**	**7**	**8**	**3**	**3**	**4**
In-Active	Center stack adjustment	6	46.15%	3	1	0	0	0	0	2
	No secondary tasks	3	23.08%	1	0	0	0	1	1	0
	Food/drink	2	15.38%	0	0	0	1	0	0	1
	Cell phone visual/manual	1	7.69%	1	0	0	0	0	0	0
	External distraction	1	7.69%	1	0	0	0	0	0	0
	Total	**13**	**100%**	**6**	**1**	**0**	**1**	**1**	**1**	**3**

Table A4-3. Driver Behavior Frequency by ADAS Activation, Training Type, and GPS Location

L2 Status	Driver Behaviors	Total Frequency Count	Total Percentage	GPS Point						Non-GPS Point
				1	2	3	4	5	6	
Video Training Group										
L2 Active	None	107	84.92%	19	15	19	15	19	20	–
	Exceeded speed limit	7	5.56%	1	1	1	1	2	1	–
	Lane drifting	7	5.56%	0	2	0	4	0	1	–
	Drowsy, sleepy, asleep, fatigued	4	3.17%	1	1	1	0	1	0	–
	Passing on right	1	0.79%	0	0	1	0	0	0	–
	Total events	**126**								
L1 Active	None	34	79.07%	5	7	4	8	5	5	–
	Exceeded speed limit	7	16.28%	2	2	1	0	1	1	–
	Drowsy, sleepy, asleep, fatigued	1	2.33%	0	0	1	0	0	0	–
	Passing on right	1	2.33%	0	0	0	0	0	1	–
	Total events	**43**								
None Active	None	8	66.67%	1	2	1	1	2	1	–
	Lane drifting	4	33.33%	1	0	1	1	0	1	–
	Total events	**12**								
Interactive Training Group										
L2 Active	None	161	93.60%	16	24	25	20	27	27	22
	Exceeded speed limit	5	2.91%	2	0	1	2	0	0	0
	Lane drifting	4	2.33%	1	0	0	2	0	0	1
	Passing on right	1	0.58%	0	0	0	0	0	0	1
	Speeding or other unsafe actions in work zone	1	0.58%	1	0	0	0	0	0	0
	Total events	**172**								
L1 Active	None	32	94.12%	9	4	4	6	3	3	3
	Driving slowly: below speed limit	2	5.88%	0	1	0	0	0	0	1
	Total events	**34**								
None Active	Exceeded speed limit	2	20.00%	1	0	0	0	0	1	0
	Lane drifting	0	0.00%	0	0	0	0	0	0	0
	None	8	80.00%	3	1	0	1	1	0	2
	Total events	**10**								