Final Report

Public Awareness on Distracted Driving of CAVs and Evaluating the Distractions

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16. Abstract

Distracted driving is a major concern in traffic safety, leading to many fatal crashes in the United States in recent years. Every year, distracted driving costs lives. In the U.S., distracted driving claims the lives of nine people per day. With the increasing presence of CAV technologies, there is a corresponding rise in the quantity of auditory and visual notifications and warnings for drivers. Consequently, the need to examine the potential adverse impacts of these notifications on drivers is growing. The main goal of this project is to decrease the number of distracted driving crashes in Maryland by educating drivers and investigating different CAV technologies. To achieve this goal, an online webinar was conducted to educate drivers regarding distracted driving due to new CAV technologies, as well as how drivers can avoid distractions and crashes caused by distractions. The online webinar was held on April 28, 2023, with a total of 34 participants. In the webinar, the research team discussed all of the CAV technologies, warnings and notifications and their association with distracted driving. Moreover, a driving simulator and eye-tracking system was used to assess the effects of different CAV notification and warning modality types (auditory, visual, and bimodal) on drivers' and gaze behaviors. Thirty-five participants wore eye trackers while driving in a simulated network across four scenarios. The participants also completed pre- and post-survey questionnaires. Based on the results of the ANOVA with a post-hoc test, there was a significant difference in throttle and steering velocity changes between scenarios. It suggests that when drivers were presented with a visual warning, their focus was diverted from the road, and as a result, they failed to adapt to the changing driving environment, resulting in rapid changes in the direction of the vehicle. The results of the eye tracker and heatmaps demonstrated that during the visual and bimodal warnings, participants' gaze fixations were primarily focused on the CAV warnings rather than the road. The longer gaze fixation for visual warnings suggests that the presence of additional auditory cues in the bimodal scenario may have influenced participants to shift their attention more quickly between the warning and the road environment. Participants preferred bimodal alerts and acknowledged the positive influence of the CAV warning on their safety. The results emphasize the significance of combining several modalities to improve the effectiveness of CAV warnings.

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LIST OF ACRONYMS

NHTSA	the National Highway Traffic Safety Administration
AV	Automated Vehicle
CV	Connected Vehicle
CAV	Connected and Automated Vehicle
LDWS	Lane departure warning systems
LCAS	Lane centering assist systems
ACC	Adaptive cruise control
FCW	Forward collision warning
NVS	Night vision systems
ADAS	Advanced Driver Assistance System
DDS	Drowsiness Detection Systems
AR	Augmented Reality
HUD	Heads-up Displays
DMS	Driver Monitoring Systems
AEB	Automatic Emergency Braking Systems
AFS	Adaptive Front Lighting Systems
AI	Artificial Intelligence

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ABSTRACT

Distracted driving is a major concern in traffic safety, leading to many fatal crashes in the United States in recent years. Every year, distracted driving costs lives. In the U.S., distracted driving claims the lives of nine people per day. With the increasing presence of CAV technologies, there is a corresponding rise in the quantity of auditory and visual notifications and warnings for drivers. Consequently, the need to examine the potential adverse impacts of these notifications on drivers is growing. The main goal of this project is to decrease the number of distracted driving crashes in Maryland by educating drivers and investigating different CAV technologies. To achieve this goal, an online webinar was conducted to educate drivers regarding distracted driving due to new CAV technologies, as well as how drivers can avoid distractions and crashes caused by distractions. The online webinar was held on April 28, 2023, with a total of 34 participants. In the webinar, the research team discussed all of the CAV technologies, warnings and notifications and their association with distracted driving. Moreover, a driving simulator and eye-tracking system was used to assess the effects of different CAV notification and warning modality types (auditory, visual, and bimodal) on drivers' and gaze behaviors. Thirty-five participants wore eye trackers while driving in a simulated network across four scenarios. The participants also completed pre- and post-survey questionnaires. Based on the results of the ANOVA with a post-hoc test, there was a significant difference in throttle and steering velocity changes between scenarios. It suggests that when drivers were presented with a visual warning, their focus was diverted from the road, and as a result, they failed to adapt to the changing driving environment, resulting in rapid changes in the direction of the vehicle. The results of the eye tracker and heatmaps demonstrated that during the visual and bimodal warnings, participants' gaze fixations were primarily focused on the CAV warnings rather than the road. The longer gaze fixation for visual warnings suggests that the presence of additional auditory cues in the bimodal scenario may have influenced participants to shift their attention more quickly between the warning and the road environment. Participants preferred bimodal alerts and acknowledged the positive influence of the CAV warning on their safety. The results emphasize the significance of combining several modalities to improve the effectiveness of CAV warnings.

Keywords: Distracted Driving, Driving Behavior, CAV Technologies, Visual Warning, Auditory Warning

1. INTRODUCTION

Distracted driving is a major concern in traffic safety, leading to many fatal crashes in the United States in recent years. Every year, distracted driving costs lives. In the U.S., distracted driving claims the lives of nine people per day (*1*). According to the National Highway Traffic Safety Administration (NHTSA), distracted driving caused 3,522 deaths in 2021 (*2*). Moreover, 3,142 and 2,895 people died in distracted driving crashes in the U.S. in 2020 and 2019, respectively, reflecting a steady rise in distraction-related fatal crashes in recent years (*3*, *4*). Distractions can also result in crashes that cause serious injuries. In fact, 324,652 people were injured in distracted driving crashes in 2020 (*5*). Even when distracted for a short while, many drivers are unaware of how far they can travel. When driving at 55 mph, motorists may blindly travel the equivalent of an entire football field if they take their eyes off the road for only five seconds. Because there is so much terrain to cover, it is not surprising that when drivers get distracted, the chance of a crash increases (*1*). Although most people agree that distracted driving is a problem, not everyone agrees on what it means to be distracted. Most people associate distracted driving with using a cell phone or texting, but it can also involve other activities. Distracted driving is defined as any activity that diverts attention from driving, such as talking on the phone or texting, eating and drinking, engaging in conversation with passengers, fiddling with the stereo, entertainment, or navigation system, or engaging in any other activity (*4*). There are four types of distraction (*5*):

- Visual distractions cause a driver to move their eyes away from the road, like turning to talk to a passenger or child in the back seat.
- Auditory distractions are sounds that cause a driver's attention to shift, like listening to music or conversations among passengers.
- Manual distractions happen when a driver's hands move away from the wheel, like when eating, drinking, or using electronics.
- Cognitive distractions happen when a driver's mind wanders and they are no longer focused on driving, such as when they are preoccupied with strong emotions or are too tired to drive.

The driving environment is becoming more complex with the advancement of technology, including auditory and visual notifications (*6*). By interacting with nearby cars and infrastructure, CAVs (connected and autonomous vehicles) use both connected vehicle (CV) and autonomous vehicle (AV) technology to provide vehicle automation for driving choices (*7*). With the increasing number of CAV technologies, there is a corresponding rise in the quantity of auditory and visual notifications and warnings directed at drivers. Consequently, the need to examine the potential adverse impacts of these notifications and warnings on drivers is growing in significance. Many studies have investigated the effects of auditory and visual distractions on drivers' behavior (*6*, *8*), and numerous studies have used driving simulators to investigate drivers' behavior (*9–16*). What makes this study state-of-the-art is that it investigates the effects of all modalities of warnings for CAV technologies (auditory, visual, and bimodal (both visual and auditory)), on both driving behavior and glance behavior. This study utilized a driving simulator, which allows for controlled and repeatable conditions, enabling researchers to gather detailed data on driving performance metrics and behaviors. Additionally, in this study, an eye-tracking system is used to observe eye movement and gaze analysis. By doing so, this research addresses an important gap in literature.

1.1. Problem Statement

In this study, two main problems were discovered after examining the large number of deaths caused by distracted driving. The first problem is that although numerous researchers have conducted studies on distracted driving behaviors and have focused on different aspects of CAV, most drivers and stakeholders are not fully aware of distracted driving behaviors caused by CAV technologies, and they have not been educated about the potential safety issues of CAVs. The second problem is that despite advancing different types of CAV notification technologies, the levels of their destructiveness have never been evaluated. These problems are getting worse due to the increasing inventions of various new technologies. The CAVs will eventually use numerous driver assistance technologies, including under-vehicle cameras, voice-activated digital assistants, parking radars, digital rear-view mirrors, intelligent headlights, navigators, etc. Although these new technologies are very useful and can decrease safety issues, it is still vital that drivers minimize the chance of becoming distracted and learn how to safely use them.

1.2. Goal

The main goal of this research is to decrease the number of distracted driving crashes in Maryland by educating drivers, and to investigate different CAV technologies. To achieve this goal, the following objectives will be pursued.

- The first objective is to educate drivers by hosting an online webinar where we discuss how CAV technologies contribute to distracted driving, as well as how drivers can avoid crashes caused by the distractions.
- The second objective is to investigate the effects of different CAV notifications and warning modality types (auditory, visual, and bimodal) on drivers' behavior and gaze behavior using an eye tracker and a driving simulator that can simulate real-world circumstances without putting drivers at risk.

2. CAV TECHNOLOGIES AND DISTRACTED DRIVING

One of the primary ways in which CAV technologies might distract drivers is by taking their focus away from the road. In-vehicle displays, entertainment systems, and navigation systems, for example, all need the driver to take their eyes off the road in order to interact with the equipment. Many of these systems are voice-activated or hands-free, but using these systems can be distracting and increase the danger of a crash. The growing complexity of modern vehicles is another possible source of distraction. Many CAV technologies necessitate that drivers comprehend and employ a range of controls, such as touchscreens, buttons, and voice instructions. This complexity can lead to confusion and irritation as drivers attempt to remember how to use their vehicles' different features and settings.

The inclusion of several sensors, cameras, and other monitoring systems in modern cars is another possible cause of distraction. A driver, for example, may grow angry or frustrated by frequent lane departure warning system notifications, causing them to ignore the system or perhaps turn it off. Finally, because they are unique or entertaining, some CAV technologies can be a source of distraction. In-car entertainment systems or virtual assistants, for example, can be entertaining to use, but they can also divert drivers' attention away from the road, increasing the chance of a crash. In this section, all of the technologies related to CAV warnings and notifications and their association with drivers' behavior and distractions are described.

2.1. Lane Departure Warning Systems

Lane Departure Warning Systems (LDWS) are designed to alert drivers when they unintentionally drift out of their lane, using a variety of sensors to detect the vehicle's position relative to the road markings (*17*) (**Figure 1**). While these systems are intended to improve safety by warning drivers when they are at risk of a collision or running off the road, they can also potentially distract drivers in a few ways. One reason for this concern is that LDWS can lull drivers into a false sense of security. Drivers who have LDWS in their vehicles may be more likely to take their eyes off the road, believing that the system will warn them if they start to drift (*18*).

Another concern is that LDWS may distract drivers. For example, if an LDWS system emits a loud beep or vibrates the steering wheel, it could startle the driver and cause them to take their eyes off the road. Lane departure warning systems may generate false alarms, such as when driving on roads with faded or irregular lane markings. These false alarms can be annoying and cause drivers to pay less attention to the system in the future.

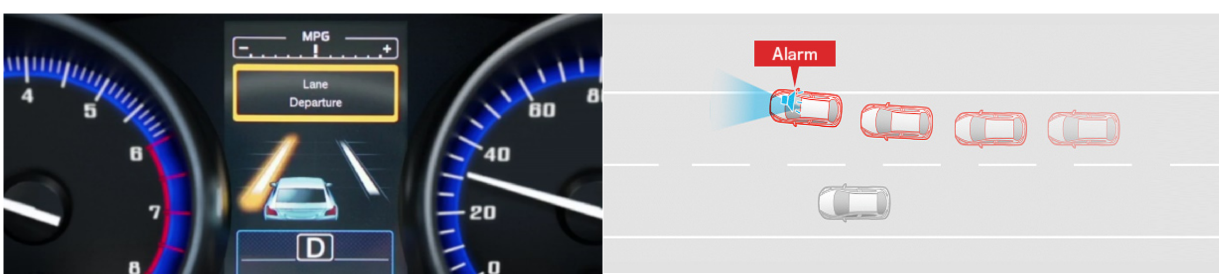


FIGURE 1 Lane Departure Warning Systems

2.2. Lane Centering Assist Systems

The lane centering assist system (LCAS) is the newest form of lane departure warning systems. Lane centering assist seeks to maintain the vehicle in the current lane. It works if the vehicle detects that a driver is holding the steering wheel lightly and ensures that the vehicle's turns are not too sharp (**Figure 2**). They can be a valuable safety feature, as lane departure is a leading cause of crashes. Lane centering assist systems can cause drivers to become over-reliant on this technology, resulting in paying less attention to the road, or to their vehicle's surroundings. The systems can also be inaccurate, and some drivers may find the frequent corrections and warnings of lane centering assist systems to be distracting or irritating (*19*, *20*).

FIGURE 2 Lane Centering Assist

2.3. Blind-spot Monitoring Systems

Blind-spot monitoring systems are designed to help drivers detect and avoid potential hazards that may be lurking in their blind spots (*21*). While blind-spot monitoring systems are generally considered to be a valuable safety feature, they can also potentially distract drivers in a few ways (**Figure 3**):

1. Overreliance: Drivers may become overly reliant on this system and stop checking their blind spots manually, assuming that the system will always detect any hazards.
2. False alarms: These can occasionally happen due to a malfunction or because the system has detected a harmless object. These false alarms can be distracting for drivers and may lead them to ignore or become desensitized to future alerts.
3. Alert fatigue: Over time, drivers may become fatigued or annoyed by the constant alerts from the blind-spot monitoring system, particularly if they are driving in heavy traffic where there are many potential hazards.

It is important for drivers to remain vigilant and continue to check their blind spots manually, even when the system is active.

FIGURE 3 Blind-spot Monitoring Systems

2.4. Adaptive Cruise Control

Adaptive cruise control (ACC) is a driver assistance technology that automatically adjusts the speed of a vehicle to keep a safe distance from the vehicle ahead (*22*). It can be a useful safety feature because it helps reduce rear-end crashes (**Figure 4**). However, there are some who believe that ACC might encourage distracted driving. A possible cause for this issue is that ACC may mislead drivers into thinking they are safe. Drivers who have ACC may be more prone to take their eyes off the road, believing that the system will keep them from crashing.

Another issue is that ACC may distract drivers. For instance, if an ACC system generates a loud notification or warning or vibrates the steering wheel, the driver may become startled and take their eyes off the road. Overall, additional investigation is required to identify the exact influence of ACC on distracted driving.

FIGURE 4 Adaptive Cruise Control

2.5. Forward Collision Warning

Forward collision warning (FCW) systems are designed to alert drivers when they are in danger of colliding with a vehicle or obstacle ahead. FCW systems use sensors and cameras to detect the distance and speed of the vehicle ahead and provide a visual or audible alert if a collision is imminent (**Figure 5**) (*23*). While FCW systems are generally considered to be a valuable safety feature, they can also potentially distract drivers in a few ways:

1. False alarms can be produced by FCW systems, either due to a malfunction or because the system has detected a harmless object, such as a roadside sign or parked car.

2. Alert fatigue: Over time, drivers may become fatigued or annoyed by the constant alerts from the FCW system, particularly if they are driving in heavy traffic where there are many potential hazards. This can lead to the driver ignoring or disabling the system, which can increase the risk of crashes.

3. Another potential problem is that drivers may assume that the FCW system will always detect any potential hazards, leading them to pay less attention to the road and other potential hazards.

Drivers should be educated about the limitations of the system and how to use it effectively to ensure that they are able to make the most of this valuable safety feature while minimizing the risk of distraction.

FIGURE 5 Forward Collision Warning

2.6. Night Vision Systems

Night vision systems are designed to improve visibility and safety while driving in low-light conditions, such as at night or in foggy weather. These systems use infrared cameras to detect heat signatures and produce an image of the road ahead on a display screen in the vehicle (**Figure 6**) (*24*). While night vision systems can be a valuable safety feature, they can also potentially distract drivers in a few ways:

1. Information overload: The additional information provided by the night vision system can be overwhelming for some drivers, particularly if they are not used to using this technology.

2. Limited visibility: Even though these systems can improve visibility in low-light conditions, they have limited use when visibility is reduced by heavy rain, snow or fog.

3. False sense of security: Drivers may develop a false sense of security when using the night vision system, assuming that they can see all potential hazards on the road.

FIGURE 6 Night Vision System

2.7. Pedestrian Detection Systems

A pedestrian detection system is a type of advanced driver assistance system (ADAS) that uses radar, LiDAR, or cameras to detect pedestrians in the vehicle's path. They also provide a visual or audible alert to the driver if a potential collision is detected (**Figure 7**). Pedestrian detection may not always be able to help avoid a collision, but this feature can help reduce the speed enough to make the impact more survivable (*25*). While pedestrian detection systems are generally considered to be a valuable safety feature, systems like pedestrian detection are not a replacement for an attentive driver, and they can distract drivers in a few ways:

1. False alarms: Pedestrian detection systems can occasionally produce false alarms, either due to a malfunction or because the system has detected a harmless object such as a tree or shadow.
2. Alert fatigue: Over time, drivers may become fatigued or annoyed by the constant alerts from the pedestrian detection system, particularly if they are driving in an area with a high density of pedestrians.
3. Complacency: Drivers may assume that the pedestrian detection system will always work, so they pay less attention to the road and other potential hazards.

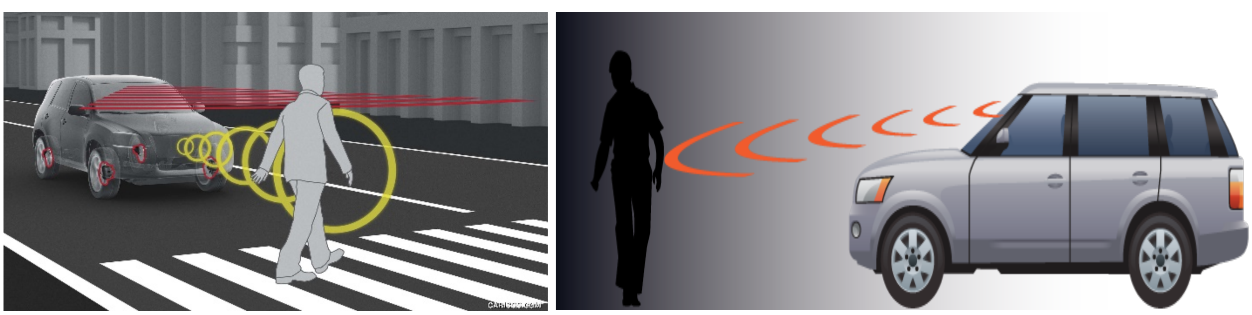


FIGURE 7 Pedestrian Detection System

2.8. Drowsiness Detection Systems

Drowsiness detection systems (DDS) are a form of advanced driver assistance system (ADAS) that monitors the driver's attentiveness and alerts them if they appear drowsy. They can be an important safety feature because they can help avoid drowsy driving, which is a major cause of crashes. These systems typically use cameras or sensors to monitor a driver's behavior and can provide a visual or audible alert if signs of drowsiness are detected (**Figure 8**). Different car models have different systems, but in most cases, a noise or vibration from the steering wheel or seat will notify the driver of their potential distraction. The system could additionally encourage the driver to take a rest, especially if they have been driving for a long time (*26*, *27*). It should be noted that DDS systems are still in development, and their safety and effectiveness are currently being assessed. Drivers must also be aware of the possible dangers of distracted driving, especially while employing DDS systems. Even while employing advanced driver assistance technologies, drivers must remain cautious and pay attention to the road. DDS systems can also potentially distract drivers in a few ways:

1. False alarms: DDS systems can produce false alarms, either due to a malfunction or because the system has detected a behavior that may not necessarily indicate drowsiness, such as a driver looking away briefly to adjust the radio. These false alarms can be distracting for drivers and may lead them to ignore future alerts.

2. Over-reliance: Drivers may become over-reliant on the drowsiness detection system to keep them alert, leading them to pay less attention to their own level of alertness or the road ahead.

3. Complacency: Drivers may assume that the drowsiness detection system will always detect any potential hazards, leading them to pay less attention to the road and other potential hazards.

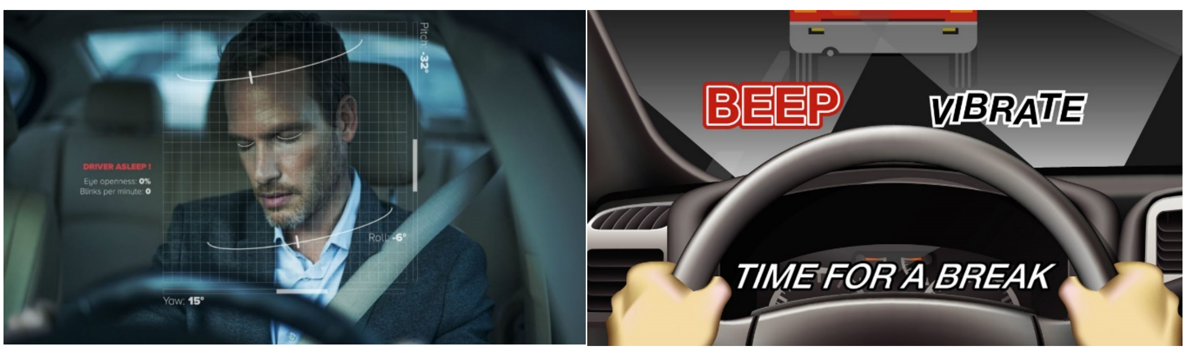


FIGURE 8 Drowsiness Detection Systems

2.9. Voice-activated Controls

In-vehicle voice commands are becoming more widespread. They enable drivers to operate numerous vehicle functions by speaking to the automobile, such as changing the radio station, making a phone call, or setting the navigation system (**Figure 9**). This can be a simple method to use these features without a driver taking their hands off the wheel or their eyes off the road (*28*). While voice-activated controls can be a convenient way for drivers to interact with in-car technology, they can also potentially distract drivers in a few ways:

1. Misrecognition or delay: Voice-activated controls may sometimes misrecognize or delay the driver's voice commands, leading to frustration or distraction as the driver attempts to repeat or clarify their request.

2. Complexity: Some voice-activated controls may be complex or require the driver to use specific phrasing or commands, leading to confusion or distraction as the driver attempts to remember how to use the system.
3. Overuse: Drivers may become overly reliant on voice-activated controls to operate in-car technology, leading them to take their eyes off the road for extended periods of time or become distracted while attempting to interact with the system.

FIGURE 9 Voice-activated Controls

2.10. Augmented Reality Displays

Augmented Reality (AR) displays are a type of technology that superimposes computer-generated images onto a real-world view. They are being developed for vehicles to provide drivers with information about their surroundings, such as navigation directions, traffic information, and blind spot warnings, creating an immersive and interactive experience for users (**Figure 10**). Cars with augmented reality options are still few and far between, but there are some concerns that AR displays would lead to distracted driving (*29*).

This is due to the fact that they can be visually distracting and divert the driver's attention away from the road. For instance, if an augmented reality display is utilized to convey navigation directions, the motorist may be enticed to stare at the display rather than the road. Moreover, interacting with an AR display may require a driver to use their cognitive resources, leading to a reduced ability to focus on the road or react quickly to potential hazards. Drivers may also become over-reliant on the information provided by an AR display, leading them to pay less attention to the road and other potential hazards.

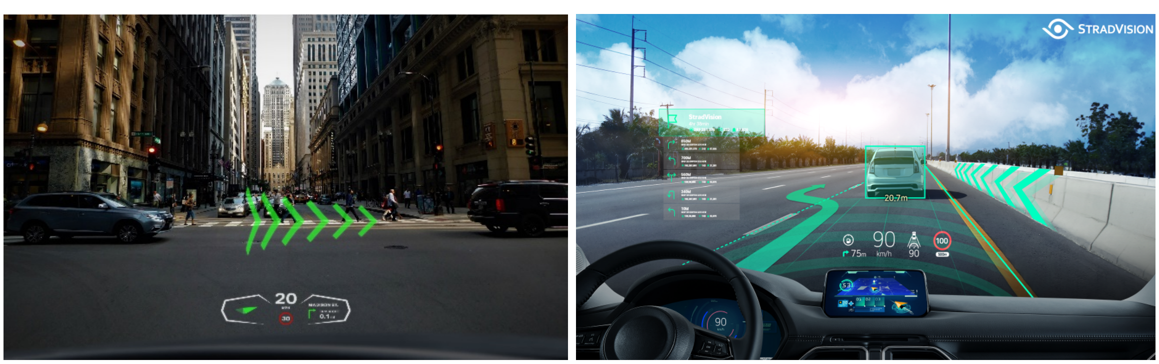


FIGURE 10 Augmented Reality Displays

2.11. In-vehicle Displays

In-vehicle displays, including infotainment screens and navigation systems, and gesture and touch-based controls, can be a source of distraction for drivers, as they require drivers to take their eyes and attention off the road (**Figure 11**) (*30*, *31*). There are some ways these technologies can distract drivers:

1. Visual distraction: In-vehicle displays need drivers to look at and interact with the screen, which can induce visual distraction. This implies that drivers may be distracted and miss vital information or risks on the road ahead.
2. Cognitive distraction: In-vehicle displays can also induce cognitive distraction, which means that drivers are thinking about things other than driving.
3. Manual distraction: In-vehicle displays may force drivers to take their hands off the wheel, resulting in manual distraction. As a result, drivers may have less control over their vehicles and may be less able to adapt to rapid changes in traffic.

FIGURE 11 In-vehicle Displays

2.12. Entertainment Systems

Entertainment systems in cars are becoming increasingly sophisticated, including features like touch screens, built-in DVD players, and satellite radio (**Figure 12**) (*32*). There are a few ways in which these systems can distract drivers:

1. Visual distraction: Theses systems can be visually engaging, and drivers may be tempted to watch a movie or video instead of focusing on the road ahead.
2. Cognitive distraction: Watching a movie or video can be cognitively demanding, and drivers may become absorbed in the content, leading to a reduced ability to focus on the road.
3. Auditory distraction: Loud or distracting audio from entertainment systems can also be a major distraction for drivers, reducing their ability to hear important cues or warnings from other safety systems.

In general, it is best to avoid using entertainment systems while driving and save these activities for times when the car is parked or stopped.

FIGURE 12 Entertainment Systems

2.13. Heads-up Displays (HUDs)

Heads-up displays (HUDs) are a type of technology that projects information such as speed, navigation, and other relevant data onto the windshield in front of the driver. Although it is mainly a tool for gathering information, it is also a safety feature. It delivers different types of information without requiring the driver to look away from the road. Several developers have developed HUD applications, which artificially produce a HUD display by reflecting vehicle information from the phone onto the vehicle's windshield in the same way as the built-in HUD (**Figure 13**) (*33*).

While HUDs are intended to minimize driver distraction by allowing drivers to keep their eyes on the road, they can also potentially cause distraction in a few ways:

1. Overload of information: HUDs can potentially display a lot of information at once, leading to an overload of visual stimulation that may distract drivers from the road ahead.
2. Misinterpretation of information: HUDs may also display information that is difficult to interpret or understand, leading to the need for additional interactions or attempts to read the information.
3. Display malfunctions: Technical malfunctions or glitches with the HUD system may cause the display to malfunction, leading to additional distractions and potential safety hazards.

FIGURE 13 Heads-up Displays

2.14. In-car Gaming Systems

In-car gaming systems are relatively new technology that have the potential to distract drivers from the road ahead. While in-car gaming systems can be a fun and entertaining way to pass the time on long drives, they can also pose a significant distraction risk to drivers (**Figure 14**). These systems typically feature games that can be played by passengers in the back seat or by the driver during periods of low traffic or when the car is parked (*34*). There are a few ways in-car gaming systems can distract drivers:

1. Visual distraction: These systems often include bright and colorful graphics that can draw a driver's attention away from the road ahead. This can cause a driver to miss important visual cues, such as road signs, traffic lights, or other vehicles.
2. Cognitive distraction: Even if a driver is not actively playing a game, the presence of an in-car gaming system can be a cognitive distraction. This is because the driver may be tempted to start playing a game or may be distracted by the sounds and visuals of the game being played by a passenger in the back seat.
3. Malfunctions and technical issues: As with any technology, in-car gaming systems may experience malfunctions or technical issues that can cause additional distractions or safety hazards.

FIGURE 14 In-car Gaming Systems

2.15. Driver Monitoring Systems

Driver monitoring systems (DMS) are a form of advanced driver assistance system (ADAS) that monitors the driver's attention and conduct using cameras, sensors, and artificial intelligence. These systems can identify whether or not the driver is tired, distracted, or paying attention to the road. If the system identifies an issue, it can either inform the driver or take control of the car (**Figure 15**).

By detecting and alerting drivers who are not paying attention to the road, DMS has the potential to reduce distracted driving. However, there is considerable fear that DMS may result instead in distracted driving. This is because drivers may become complacent and rely entirely on the system.

FIGURE 15 Driver Monitoring Systems

2.16. Traffic Sign Recognition Systems

Traffic sign recognition systems use cameras and image recognition software to detect and identify traffic signs, such as speed limit signs and stop signs. The system notifies the driver when a speed limit sign or other traffic sign is detected, keeping the driver informed of speed limit changes and other important road information (**Figure 16**) (*35*, *36*). There are a few ways in which traffic sign recognition systems could potentially distract drivers:

1. Over-reliance: If drivers become too reliant on traffic sign recognition systems, they may start to assume that the system will always detect and alert them to traffic signs, even if they are not paying full attention to the road.
2. False positives: If a traffic sign recognition system is not properly calibrated, it may generate false positives, alerting the driver to non-existent traffic signs.
3. Information overload: If a traffic sign recognition system generates too many alerts or notifications, it could potentially be a distraction for the driver.

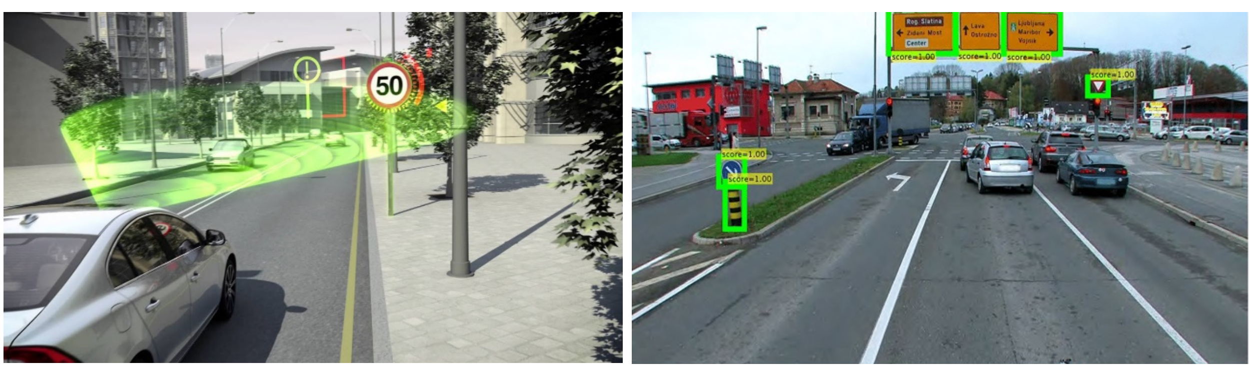


FIGURE 16 Traffic Sign Recognition Systems

2.17. Automatic Emergency Braking Systems

Automatic Emergency Braking (AEB) Systems combine various types of sensors, such as radar, video, infrared or ultrasonic sensors, to scan for possible objects in front of the vehicle and then use brake control to prevent a collision (**Figure 17**) (*37*). These systems are designed to detect potential collisions and apply the brakes automatically to prevent or mitigate a crash. They can potentially be a distraction for drivers in a few ways:

1. Over-reliance: If drivers become too reliant on AEB systems, they may start to assume that the system will always detect and prevent crashes, even if they are not paying full attention to the road.
2. False positives: If an AEB system is not properly calibrated, it may generate false positives, applying the brakes unnecessarily and potentially startling or distracting the driver.
3. Lack of attention: If drivers know that their car has an AEB system, they may be less likely to pay attention to the road and may engage in distracting activities such as using their phone or adjusting their entertainment system.

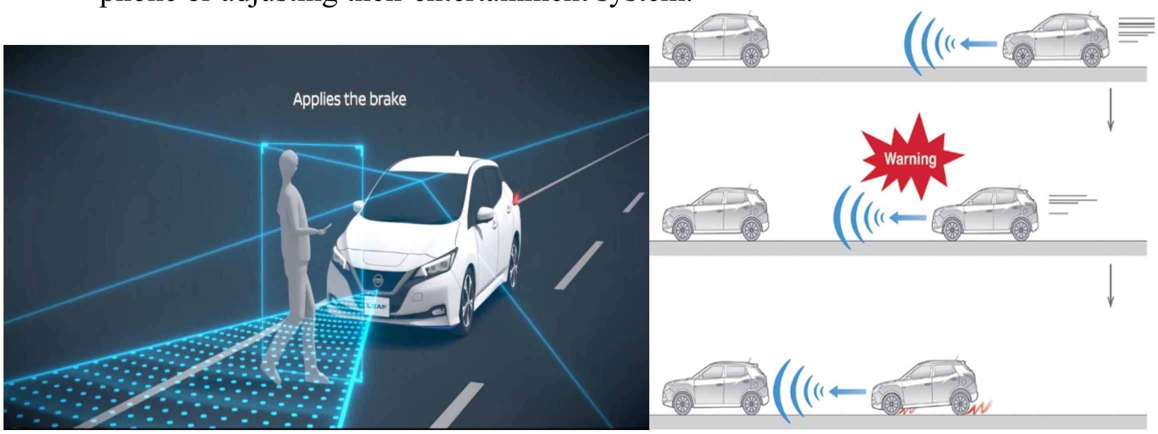


FIGURE 17 Automatic Emergency Braking System

2.18. Adaptive Front Lighting Systems

AFS is a form of advanced driver assistance systems (ADASs) that uses sensors to change a vehicle's headlights based on the driver's speed and the surrounding environment. This can help to improve visibility and safety, particularly at night or in bad weather. AFS can help decrease distracted driving by improving drivers' ability to perceive the road ahead (**Figure 18**) (*38*). It is crucial to stress, however, that AFS is not a replacement for safe driving behaviors. Drivers must remain attentive to their surroundings and avoid distractions while on the road. While AFS can improve visibility and safety in certain situations, they can also potentially distract drivers in several ways:

1. Over-reliance on technology: Drivers may become overly reliant on AFS and assume that their vehicle's headlights will always adjust automatically to provide optimal visibility. This could lead to a false sense of security and make drivers less attentive to the road.
2. Inconsistent lighting: AFS can cause the headlights to change direction or intensity frequently, which can be distracting for drivers.
3. Glare: In some cases, AFS can create glare or reflections that can temporarily blind or distract drivers. This can happen when the headlights are directed at reflective surfaces such as road signs or other vehicles.
4. Technical malfunctions: AFS relies on complex technology, which can sometimes malfunction or fail.

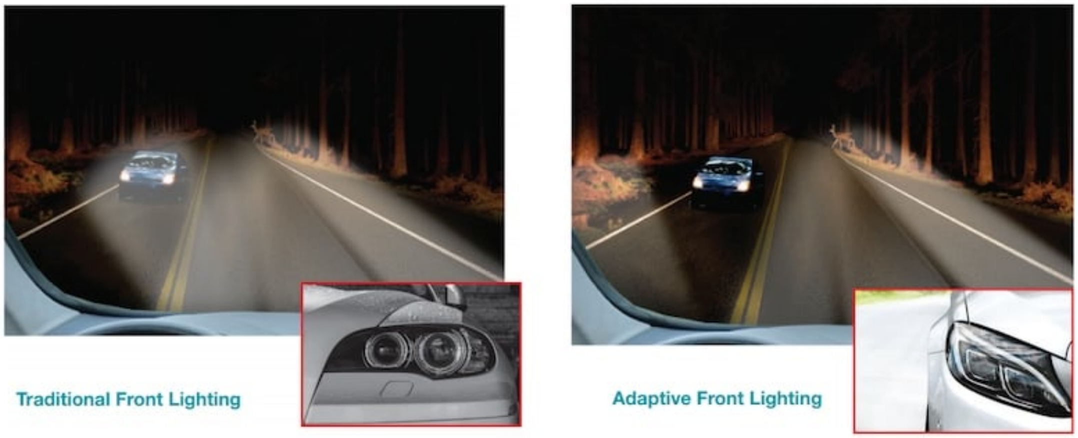


FIGURE 18 Adaptive Front Lighting Systems

2.19. Self-driving or Autonomous Driving Systems

A self-driving car (sometimes called an autonomous car or driverless car) is a vehicle that uses a combination of sensors, cameras, radar and artificial intelligence (AI) to travel between destinations without a human operator (**Figure 19**) (*39*). These systems use a variety of sensors, including cameras, radar, and LiDAR, to perceive their surroundings and make decisions about how to navigate. There is some concern that self-driving cars could lead to distracted driving. This is because drivers may become complacent and rely on the system to do all the work. If something goes wrong with the system, the driver may not be prepared to take over.

FIGURE 19 Autonomous Driving Systems

3. DISTRACTED DRIVING AND POTENTIAL DISTRACTIONS OF CAV TECHNOLOGIES WEBINAR

On April 28, 2023, the research team conducted a webinar to educate Maryland drivers about CAV warnings and notifications, and technologies and their association with distracted driving. **Figure 20** shows the outline of the webinar.

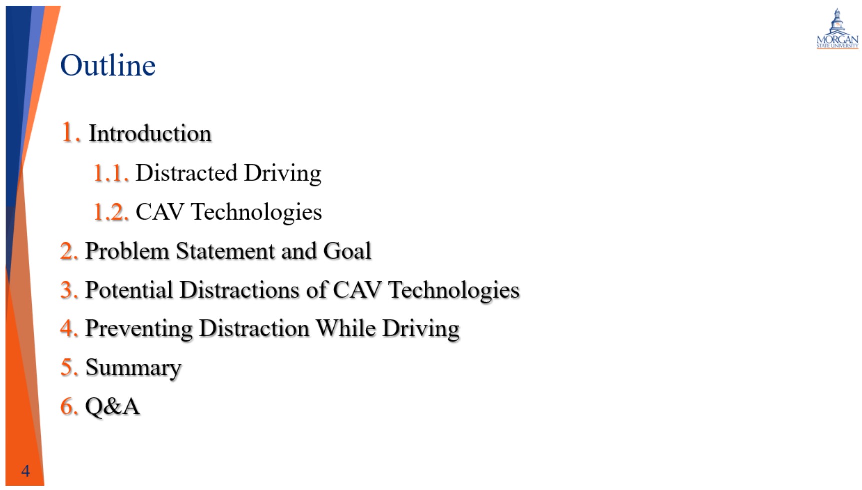


FIGURE 20 Distracted Driving Webinar Outline

The webinar started with an introduction to distracted driving, explaining the issue, relevant facts, and statistics about the dangers of distracted driving. CAV technologies and potential distractions of CAV technologies were presented to the audience (**Figure 21**).

FIGURE 21 Distracted Driving Webinar – CAV Technologies

Next, 20 CAV technologies, warnings and notifications and their association with distracted driving were explained to the audience (**Figure 22**).

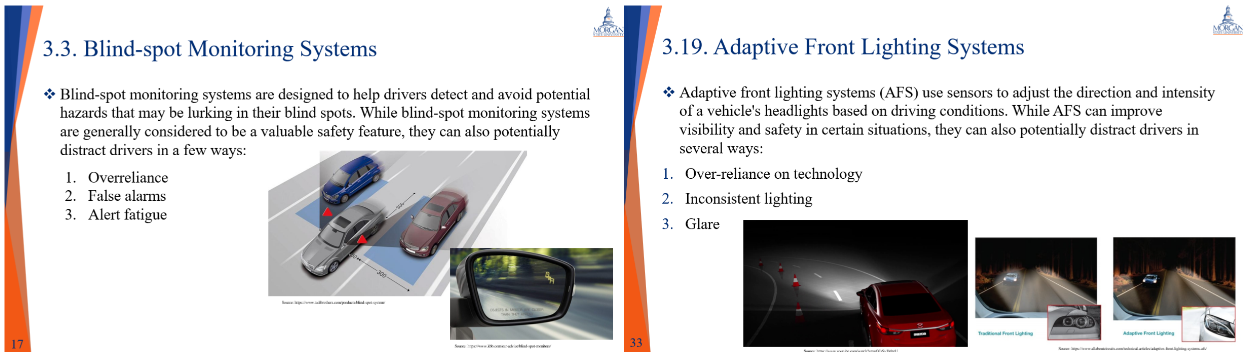


FIGURE 22 Distracted Driving Webinar – Different Types of CAV Technologies

Moreover, after explaining the technologies, some tips and routines to prevent distractions caused by CAV technologies were explained to the audience (**Figure 23**).

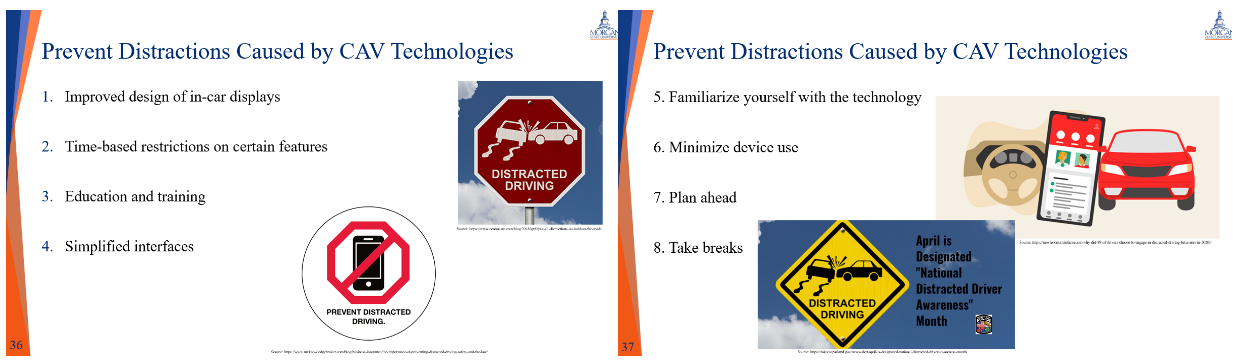


FIGURE 23 Distracted Driving Webinar – Distracted Driving Campaigns

In the end, a summary of all the technologies was presented to the audience followed by a Q&A. Overall, 43 people registered for the webinar, and 34 people joined the webinar. The link to the webinar recording can be found at the following link: https://www.youtube.com/watch?v=1cOAW-DpxlA&list=PL3tN3CUqYVDDzxjrnW2MtrX-LY-JvDzqt&index=2

4. EVALUATING THE IMPACT OF CAV NOTIFICATIONS AND WARNINGS ON DRIVERS' BEHAVIOR IN THE DRIVING SIMULATOR

Many drivers are unaware of how far they can travel when they are distracted. When driving at 55 mph, motorists may blindly travel the equivalent of an entire football field if they take their eyes off the road for only five seconds. Because there is so much terrain to cover, it is not surprising that when drivers get distracted, the chance of a crash increases (*1*). Although most people agree that distracted driving is a problem, not everyone agrees on what it means to be distracted. Most people associate distracted driving with using a cell phone or texting, but it can also involve other activities. Distracted driving is defined as any activity that diverts attention from driving, such as talking on the phone or texting, eating and drinking, engaging in conversation with passengers, fiddling with the stereo, entertainment, or navigation system, or engaging in any other activity (*4*). There are four types of distraction: visual (taking the eyes off the road), manual (taking the hands off the wheel), auditory (sounds that cause the attention to shift), and cognitive (taking your mind off driving) (*5*).

CAV technology also aims to improve drivers' situational awareness through audible and visual warnings, thus reducing the likelihood of crashes caused by human error (*40*). Recent studies have shown that CVs can help improve traffic mobility and safety while saving energy and reducing emissions (*41*). Along with these devices that help drivers avoid distractions while driving, there are others that may help lessen the probability of a crash if the driver becomes distracted. Lane departure warnings, automatic cruise control, and active lane assist are several CAV technologies available in today's market (*42*).

The driving environment is becoming more complex with the advancement of technology, including auditory and visual notifications (*6*). By interacting with nearby cars and infrastructure, CAVs use both connected vehicle (CV) and automated vehicle (AV) technology to provide vehicle automation for driving choices (*7*). With the increasing number of CAV technologies, there is a corresponding rise in the quantity of auditory and visual notifications and warnings. Consequently, the need to examine the potential adverse impacts of these notifications and warnings on drivers is growing in significance. Many studies have investigated the effects of auditory and visual distractions on drivers' behavior (*6*, *8*), and numerous studies have used driving simulators to investigate drivers' behavior (*9–16*). What makes this study state-of-the-art is that it investigates the effects of all modalities of warnings for CAV technologies (auditory, visual, and bimodal (both visual and auditory)) on driver's behavior and glance behavior. This study utilized a driving simulator, which allows for controlled and repeatable conditions, enabling researchers to gather detailed data on driving performance metrics and behavior. Additionally, an eye-tracking system was used in this study to observe eye movement and gaze analysis. By doing so, this research addresses an important gap in literature. Most of the studies focus on the effects of auditory/visual warning messages on drivers' reaction times and workload (*8*, *43–45*). However, to the best knowledge of the authors, no study evaluated the impacts of different auditory, visual, and bimodal warnings on drivers' behavior and distraction in a driving simulator.

The goal of this project is to investigate the effects of different CAV notification and warning modality types (auditory, visual, and bimodal) on drivers' behavior and gaze behavior using a driving simulator and eye tracker. To reach this goal, four different scenarios were performed to compare auditory, visual, and bimodal notifications with a base scenario (no notification).

4.1. Methodology

This study used a high-fidelity driving simulator at the Safety and Behavioral Analysis (SABA) Center at Morgan State University and the Tobii Pro Glasses 2, a head-mounted Mobile eye-tracking system (*46*) that is used to investigate the effects of different CAV notifications and warning modality types (auditory, visual, and bimodal) on drivers' behavior and gaze behavior. Driving simulators (DS) are typically used to observe how a driver reacts to hypothetical events or functions that cannot be tested safely in an actual vehicle (*47*, *48*). **Figure 24** shows the driving simulator environment.

Figure 24 The Driving Simulator

Moreover, eye-tracking data has been used substantially in studies to determine what drivers look at in different traffic conditions and how they distribute their glances when they are distracted (*49*). In this study, fixation data points will be used to create heat maps, with the eye tracker grouping raw entry records into fixations. The eye tracker generates eye gaze data that is mapped to a relative coordinate system of the eye tracking device. The Tobii Pro Lab software maps the gaze points to static objects within the simulated environment to accomplish real-world mapping. The number of fixations produced by participants in specific places can be used to generate a heat map, with the color red representing the most fixations, and green suggesting the fewest fixations. The generated heat map simply counts the number of fixations on the object or area of interest. **Figure 25** shows the eye tracker.

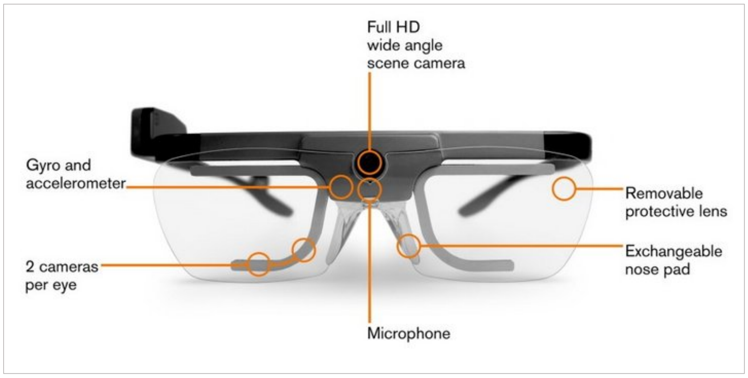


Figure 25 Tobii Pro eye tracking system

4.2. Process and Scenarios

To determine the impacts of their experiences on their driving behaviors, participants were asked to complete a pre-survey questionnaire, drive for approximately ten minutes in various simulated scenarios, and then complete a post-survey questionnaire. First, the observer gave the participants a brief description of the simulator to familiarize them with its environment. The 30 participants also reviewed the procedure before driving. To evaluate driver performance, participants completed the scenarios in a driving simulator that used three 40-inch LCD panels to exhibit the simulation. Participants sat in the driver's compartment of the simulator, which offered a view of the road and dashboard instruments such as a speedometer (**Figure 24**). Realistic engine noises, road noises, and passing traffic sounds were provided as well. After the participants sat in the simulator, they also wore the eye tracker (**Figure 25**).

The participants drove on a six-kilometer-long network that consisted of six scenarios. A major three-lane road (three 12-foot lanes) with a speed limit of 55 mph was designed using VR Studio software. A level of service B, i.e., light traffic, was used in these scenarios, so that the participants did not slow down due to high traffic, which may have been the case otherwise, creating issues when evaluating distracted driving. Traffic flow and density were the same in all six scenarios. The first and last scenarios, which were the first and the last kilometer, were warm-up and cool-down phases designed so that the participants became used to driving in the simulated environment. In the second scenario, which was from kilometer one to kilometer two, the participants drove in a base scenario with no distractions or CAV warnings. The third scenario included an auditory alert that warned the drivers of a work zone area located 350 meters ahead. In the fourth scenario, the participants received another visual alert at the same location as the previous scenario, warning the driver of the work zone ahead. In the fifth scenario, the participants received the bimodal alert (both auditory and visual warnings). **Figure 26** shows the network structure of the study.

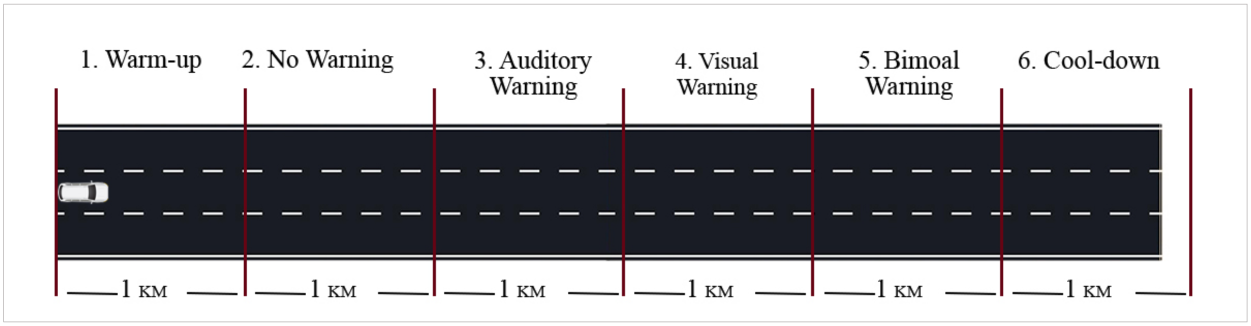


Figure 26 The Network of the Study

4.3. Data

The pre-survey asked about the participants' demographics and the different types of CAV warnings they installed in their cars. The post-survey included questions related to their experience after driving and their driving behavior while receiving each CAV warning. Apart from pre-survey and post-survey data, several driving-related data were exported from the driving simulator and eye tracker. These variables will be explained in the following sections. The research team conducted an IRB-approved driving task (IRB #23/06-0137) (**APPENDIX C**). The purpose of the IRB review is to assure, both in advance and by periodic review, that appropriate steps are taken to protect the rights and welfare of humans participating as subjects in the research. To determine the impacts of their experiences on their driving behaviors, participants were asked to sign a consent form to complete a pre-survey questionnaire, drive for approximately ten minutes in various simulated scenarios, and then complete a post-survey questionnaire. For this study, participants were recruited from Morgan State University and the Baltimore metro area via flyers that were distributed manually and online and contained an outline of the study's details. All participants were required to hold a valid driver's license, drive on a regular basis, and own a smartphone. After eligibility checks, potential participants were scheduled to drive in a simulated environment. Eventually, thirty-five licensed participants drove in the simulator under several scenarios, which will be explained in the following sections. The data retrieved from the participants were analyzed and several variables were investigated, such as throttle, which is the input on the acceleration pedal. It is a ratio with a value between 0 (no Throttle) and 1 (Full Throttle). Another variable investigated in this study is steering velocity, which is the rotation rate of the steering wheel (Unit: 1/second).

4.4. Results

4.4.1. Pre-survey Questionnaire Results

Table 1 shows the results of the pre-survey questionnaire (**APPENDIX A**). The results show that 51.43% of the participants were male, while 48.57% were female. The age of participants ranged from 16 to 45 years old.

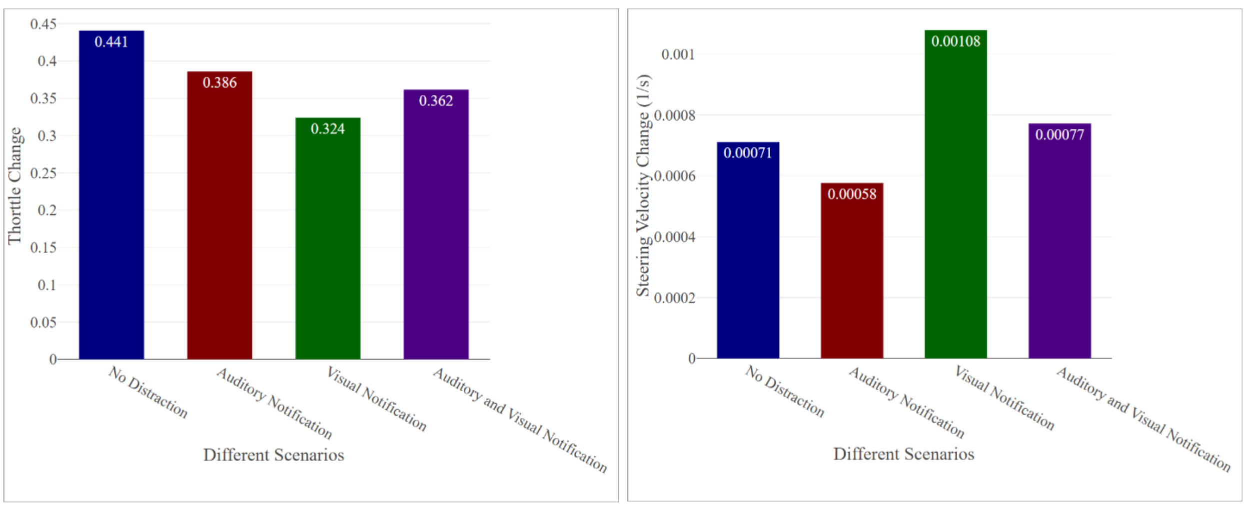
TABLE 1 Variables Used in This Study

Variable	levels	Frequency	Percentage
Gender	Female	17	48.57%

	Male	18	51.43%
Age	16-25	17	48.57%
	26-35	10	28.57%
	36-45	4	11.43%
Race	African American	19	54.29%
	White	9	25.71%
	Asian	3	8.72%
	Hispanic or Latino	1	2.86%
	Other	3	8.57%
Type of CAV Modality in Participants' Vehicle	Auditory Notifications	9	25.71%
	Visual Notifications	2	5.71%
	Both	13	37.14%
	None	6	17.14%
	Do not have a car	5	14.29%

4.4.2. Driving Simulators Results

Many studies use statistical analysis to develop policies to improve traffic safety (*11*, *50–52*), investigate and forecast travel behavior (*53*, *54*), and pinpoint deficiencies in transportation policies (*55–61*). In the first step of this study, a descriptive statistic was conducted to demonstrate the changes in variables in different scenarios. **Figure 27** shows the throttle change and changes in steering velocity under different scenarios.



(a) (b)

Figure 27 (a) Throttle Change and (b) Steering Velocity Change in Different Scenarios

Moreover, ANOVA tests were conducted to compare driving behaviors under different scenarios and conditions. To compare the statistical differences, a 5% significance level was used in this study. **Table 2** shows the results of the analysis and reveals the significant differences between variables in different scenarios.

TABLE 2 ANOVA Test

Variable		Df	Sum Sq	Mean Sq	F value	P-value
Throttle	Scenarios	3	0.251	0.08369	3.344	0.0212

	Residuals	136	3.404	0.02503		
Steering Velocity	Scenarios	3	4.74e-06	1.580e-06	2.423	0.0685
	Residuals	136	8.87e-05	6.522e-07		

Moreover, to show where these differences are significant, an ANOVA with a post-hoc Tukey HSD test was conducted. **Table 3** shows the results of these tests.

TABLE 3 Post Hoc Tukey Test Analysis Results

		Throttle		**Steering Velocity**	
Scenarios		Diff	P adj	Diff	P adj
Auditory Warning	No-Warning	-0.05482	0.470887	-1.34E-04	0.898501
Visual Warning	No-Warning	-0.11666	**0.013031**	3.68E-04	0.230291
Bimodal Warning	No-Warning	-0.07909	0.161068	6.12E-05	0.988918
Visual Warning	Auditory Warning	-0.06184	0.362442	5.02E-04	**0.049872**
Bimodal Warning	Auditory Warning	-0.02428	0.918184	1.96E-04	0.74211
Bimodal Warning	Visual Warning	0.037562	0.753511	-3.07E-04	0.38826

In **Table 3,** it can be concluded that throttle change was statistically significant between the visual warning scenario and the no-warning scenario. Moreover, steering velocity change was statistically significant between the visual warning scenario and the auditory warning scenario.

4.4.3. Eye Tracking Results

For the gaze analysis, heatmaps were created using Tobii Pro Lab for all four scenarios (no-warning, auditory warning, visual warning, and bimodal warning) during the time that participants received the CAV warning. Heatmaps are visual representations of the general distribution of gaze points. They are often demonstrated as a color gradient overlay on the image or stimulation being displayed. The red, yellow, and green colors represent, in descending order, the number of gazing points directed toward different regions of the image. Areas without coloring were likely not attended to at all. Using a heatmap is a simple way to quickly see which elements attract more attention than others (*62*). **Figure 28 (a)** shows the heatmap for the no-warning scenario, and **Figure 28 (b)** shows the heatmap for the auditory warning scenario for a duration of ten seconds.

(a) (b)

Figure 28 (a) No-Warning and (b) Auditory Warning Scenario Heatmaps for 10-Second Duration

Figure 29 (a) shows the heatmap for the visual warning scenario, and **Figure 29 (b)** shows the heatmap for the bimodal warning scenario for a duration of ten seconds.

(a) (b)

Figure 29 (a) Visual and (b) Bimodal Warning Scenario Heatmaps for 10-Second Duration

Figures 28 (a) and (b) show that most gaze fixations were on the road for no-warning and auditory warning scenarios. However, **Figure 29 (a) and (b)** shows that in visual and bimodal scenarios, gaze fixation was on the CAV warning, which is a significant amount of distraction that could lead to a collision. Moreover, AOIs (areas of interest) were carefully set to capture gaze fixations as precisely as possible. Based on the placement and content of the CAV warnings, the expectation is to see participants looking at the visual and bimodal warnings for a certain amount of time. Based on the eye tracking analysis, the average time that the participants looked at visual warnings was 3.52 seconds and 2.02 seconds for bimodal. ANOVA results show that average durations are statistically different between the two scenarios (**Table 4**).

TABLE 4 ANOVA Analysis Results for AOI Fixation Duration

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	39.386	1.000	39.386	22.310	0.000	3.982
Within Groups	120.045	68.000	1.765			
Total	159.431	69.000				

4.4.4. Post-survey Questionnaire Results

The post-survey questionnaire included questions about participants' experience and driving behavior after driving in the simulator (**APPENDIX B**). The post-survey questionnaire contained three questions. The first question asked about the participants' preference toward CAV warning modalities. The results showed that after the experience, 54.3% of the participants preferred the bimodal type for CAV warnings, 37.1% preferred only auditory warnings, and 8.6% preferred only visual warnings. The second question asked about which modality the participants found the most distracting. Results showed that 71.4% of participants chose visual warnings, 22.9% chose auditory warnings, 2.9% chose bimodal warnings, and 2.9% of participants chose all of the modalities. The third question asked about the participants' thoughts on CAV warnings and safety issues. Results showed that 77.1% of participants answered that these warnings increased their safety, and 22.9% answered that these warnings decreased their safety while driving.

4.4.5. Discussion

Previous studies showed the importance of different CAV warnings and their impacts on drivers' behavior. It is crucial that researchers consider the potentially negative effects that these warnings may have on drivers' behavior, both from a safety and traffic operations standpoint. In this study, the results of the ANOVA with post-hoc Tukey HSD for throttle change suggest that when drivers were presented with a visual warning, they may not actively engage in the driving task, and they may not be responsive to changes in driving conditions. Moreover, it can be a sign of distraction where their focus may be diverted from the road by the visual warning, and as a result, they fail to adapt to the changing driving environment. Also, a high steering velocity change in the visual warning scenario suggests that the driver is making quick and significant adjustments to the steering input, resulting in rapid changes in the vehicle's direction. This could be due to visual warning distractions, and this lack of situational awareness can impact steering behavior, including high steering velocity changes when trying to regain control.

The results of the eye tracker demonstrated the gaze behavior of the participants during different scenarios. The heatmaps provided insight into where participants directed their attention during the scenarios, shedding light on potential distractions and areas of interest. The heatmaps suggest that most gaze fixations were on the road for no-warning and auditory warning scenarios. However, during the visual and bimodal warnings, participants' gaze fixations were primarily focused on the CAV warnings rather than on the road. This implies that these two types of warnings can take a significant portion of the participant's attention away from the road and the task of driving. This might have serious consequences for driving safety, since the focus on warning displays could raise the chance of missing essential information. Previous studies showed that taking the eyes off the road for five seconds at 55 mph is equivalent to traveling the length of a football field without looking (*1*), and the results of the heatmaps show the gaze fixation for the duration of ten seconds, which can suggest that visual and bimodal warnings can create potential distractions from the primary task of driving leading to safety concerns.

The results of the post-survey questionnaire after the driving experiment suggest that more than half of the participants (54.3%) preferred the bimodal type for CAV warnings, which combines both auditory and visual modalities. This indicates that integrating multiple modalities can enhance the effectiveness and perception of warnings among drivers. Moreover, most of the participants (71.4%) found visual warnings to be the most distracting. However, 77.1% of the participants responded that CAV warnings had a positive impact on their perception of safety while driving.
The statistically significant difference in average fixation duration between visual and bimodal scenarios shows the importance and impacts of different CAV warnings, gaze behavior, and distraction. The longer gaze fixation for visual warnings suggests that the presence of additional auditory cues in the bimodal scenario may have influenced participants to shift their attention more quickly between the warning and the road environment. The results also emphasize the significance of combining several modalities to improve the effectiveness of CAV warnings. The visual warning results were the most distracting and show that careful design is required to minimize distraction. Most participants, however, stated that CAV alerts improved their safety,

emphasizing the need to deploy effective warning systems to support drivers' perception and conduct on the road.

5. SUMMARY AND CONCLUSION

There are several ways to prevent drivers from getting distracted. This project first reviewed all available CAV notifications and assessed their potential to distract drivers. An online webinar was then conducted to educate Maryland drivers on these findings. Overall, 34 people attended the webinar.

Previous studies suggested that even a quick system training can help users engage with CAV technology. Still, more research is required to determine what kind of training is needed and how frequently it should be given for it to be successful. Additional studies are also needed to make sure that the presentation of warnings (auditory, visual, and/or bimodal) is optimized, especially for distracted drivers (*63*). Therefore, the goal of this study was to investigate the effects of different CAV notification and warning modality types (auditory, visual, and bimodal) on drivers' behavior and gaze behavior using a driving simulator and eye tracker. To reach this goal, four different scenarios were performed to compare auditory, visual, and bimodal notifications with a base scenario (no notification).

A total of 35 participants drove four simulated scenarios using a driving simulator and eye tracker in a realistic road network. The results showed that drivers may be distracted and less attentive to changing driving conditions if visual warnings are presented. According to the gaze behavior analysis, visual and bimodal warnings can shift participants' attention away from the road, potentially causing safety problems. Moreover, participants preferred bimodal alerts and acknowledged the positive influence of CAV warnings on their safety. As one of the key findings of the study, it became evident that the impact of these technologies on driver behavior and distraction levels could be significantly influenced by the presence of proper training and education. To use these technologies effectively, drivers must consider the importance of training and education. Properly trained drivers may be better equipped to handle these technologies, leading to reduced distraction and improved driving safety. While warnings are crucial for driver safety, they should be designed to minimize distractions and promote appropriate allocation of attention. Future research could focus on refining the design of CAV warnings, and consider factors such as the timing, presentation format, and the integration of multimodal cues to ensure effective communication while minimizing potential distractions and maintaining drivers' attention on the road.

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7. APPENDIX A. PRE SURVEY

1. What is your gender?

a) Male
b) Female

2. What is your age group?

a) 16 to 25
b) 26 to 35
c) 36 to 45
d) 46 to 55
e) 56 to 65
f) More than 65

3. What is your race?

a) American Indian, or Alaskan Native
b) Asian
c) White
d) Other

4. What type of Driver's License do you have?

a) Permanent License for regular vehicles class C
b) Permanent License for all types of vehicles class B
c) Permanent License for all types of vehicles class A
d) Learner's Permit
e) Do not have a driver's license

This project is about CAV technologies. CAV stands for Connected and Autonomous Vehicles. It refers to the integration of advanced technologies in vehicles to enable them to communicate with each other and with their surrounding environment.
CAV technology notifications in cars can be classified into the following types:

1. Visual Notifications
2. Auditory Notifications
3. Bimodal (Both Visual and Auditory Notifications)

6. Based on the definition above, which types of notifications for CAV technologies do you have in your car?

a) Auditory Notifications (e.g., beeping sound)
b) Visual Notifications (e.g., heads-up display (HUD))
c) Both
d) None
e) I do not have a car

8. APPENDIX B. POST SURVEY

1. After this driving simulator study, which CAV technologies' notification do you prefer to use while driving?
   a) Auditory Notifications
   b) Visual Notifications
   c) Auditory and Visual together
   d) None

2. Which types of notifications for CAV technologies you found most distractive?
   a) Auditory Notifications
   b) Visual Notifications
   c) Auditory and Visual together
   d) All above three options

3. After this driving simulator experience, what are your thoughts on whether these CAV technologies' notifications increase or decrease your safety?
   a) The notifications increased my driving safety
   b) The notifications decreased my driving safety

9. APPENDIX C. IRB

MORGAN STATE UNIVERSITY

GROWING THE FUTURE • LEADING THE WORLD

Institutional Review Board (IRB)

July 7, 2023

Dr. Mansoureh Jeihani
Department of Transportation & Urban
Infrastructure Studies
Morgan State University

RE: IRB #23/06-0137

Dear Dr. Jeihani,

Following expedited review of the protocol submitted to the IRB with respect to the study being conducted in collaboration with Dr. Eazaz Sadeghvaziri , titled **"***Public Awareness on Distracted Driving of CAVs and Evaluating the Distractions***",** the study was determined to be exempt from IRB review under 45 CFR 46.104(d)(2).

Please note that it is the responsibility of the Principal Investigator to inform the IRB promptly should there be a substantive change in the study methodology as this may affect the **Exemption** determination.

Do not hesitate to contact me at benjamin.welsh@morgan.edu, or Dr. Isuk at X3447 should you have any questions.

Sincerely,

MORGAN STATE UNIVERSITY
IRB
EXEMPT
Signature: *Benjamin H. Welsh*
Date: 7/7/2023
No further action needed

Benjamin Welsh, Ph.D.
IRB Chairperson

Cc
Dr. Edet Isuk, IRB Administrator

10. APPENDIX D. CONSENT FORM

INFORMED CONSENT FORM

You are invited to participate in a study of CAV technologies and Distracted Driving. The study is being conducted by Dr. Mansoureh Jeihani of Morgan State University. You were selected as a possible participant in this study because you kindly responded to our invitation and accepted to participate.

If you decide to participate, we will ask you to fill out two survey questionnaire forms. You will be trained how to drive the simulator. It will take no more than 15 minutes. When you drive the simulator, you may feel dizzy in the first few experiments until you get used to it. There is no risk of driving the simulator, you just may feel dizzy or fatigue or get headache. You may find it fun to drive the simulator and have some experiences such as crashes that are dangerous in the real world.

Your decision whether or not to participate will not prejudice your future relation with the Morgan State University. If you decide to participate, you are free to discontinue participation at any time without prejudice.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

If you have any questions, please do not hesitate to contact us. If you have any additional questions later about the study, please contact Dr. Mansoureh Jeihani at 443-885-1873 who will be happy to answer them. If you have further administrative questions, you may contact the MSU IRB Administrator, Dr. Edet Isuk, at 443-885-3447.

You will be offered a copy of this form to keep.

You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have decided to participate. You may withdraw at any time without penalty or loss of any benefits to which you may be entitled after signing this form should you choose to discontinue participation in this study.

______________________________ ____________________

Signature **Date**

____ ____________________

Signature of Parent/Legal Guardian (If necessary) **Date**

____ ________________________

Signature of Witness (If appropriate) **Signature of Investigator**