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Influence of CAVs On Driver’s Decisions in Various Roadway Scenarios

by

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Submitted to the LSU Roger Hadfield Ogden Honors College in partial fulfillment of
the Upper Division Honors Program

April 2022

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Baton Rouge, Louisiana

Abstract

Connected and autonomous vehicles (CAVs) are projected to cause a significant change on the transportation system, roadway design, and how people travel. To maximize the benefits of CAVs in enhancing traffic safety and operation, the public's acceptance and general understanding of their capabilities is required. Indeed, for an extended period, the road environment will feature a mix of CAVs and human-driven cars. In order to assist researchers and scholars alike in further analyzing the influence of the CAVs on the transportation system, this study aims to investigate drivers' expectations, preferences, and actions in relation to a variety of CAV scenarios. The subject behind this motivation is to tackle the influence of CAVs on driver's decisions in various roadway scenarios as well as the factors that affect such choices. An online survey covering five scenarios (drivers' reactions and preferences towards CAVs on on-ramps areas, off-ramps areas, overtaking on two-way two-lane roads, overtaking on multilane highways, and driving maneuvers during adverse weather conditions) in which a driver could potentially engage with a platoon of CAVs was developed to achieve these goals. A total of 120 participants from various age groups took part in the survey. The two-way association test was then utilized to determine the significant variables that influence certain dependent questions, which were then employed in logistic regression modeling. Four logistic regression models were analyzed where it was revealed that aggressive driving behavior could be encouraged by the presence of the platoon in certain roadway scenarios (e.g., merging onto the main highway from an on-ramp lane with a platoon of CAVs on the adjacent lane; overtaking and passing a platoon of CAVs on a 2-way 2-lane road) but also potentially assist drivers in complicated road conditions and be of help for those that have less driving experience living in busier urban/suburban areas. The findings in this study reveal the tendency of drivers' decisions when confronted with a platoon of CAVs and question their preferences and willingness as well as comfortability in encountering these types of vehicles in platoon forms in a mixed traffic environment.

1. Introduction

The upcoming implementation of Connected and Autonomous Vehicles (CAVs) will force changes in the current transportation systems. The inevitable introduction of the commercially available vehicles will create a mixed traffic environment where human-driven vehicles (HDV) interact with CAVs. For HDVs, driving decisions are based on the surrounding information from the driver's perception and attentiveness to the lead vehicle as well as the following and surrounding vehicles. Downstream and upstream conditions from road, traffic, or weather conditions also play a role in a driver's safe driving experience. To prepare for the required adjustments in the current transportation system, studying driver's decisions and behaviors towards CAVs will be first dependent on maximizing the benefits from this new vehicular technology.

To begin, connected vehicles combine advanced wireless communication technology, advanced vehicle sensors, on-board computer processing, smart infrastructure, and GPS navigation to provide critical safety information to drivers. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) are two types of vehicular communication technology that provide similar surrounding information from that of a driver's visual observation, if not better detailed, regarding roadway conditions. V2V application brings awareness to vehicles downstream and upstream enhancing reaction time as information about potential accidents or sudden brakes are delivered to the connected vehicles. As for V2I communication, a breakdown of the road condition from work zones and lane closure to upstream weather situation has the potential to impact drivers' operational decisions. Autonomous vehicles, on the other hand, come in five levels of automation. The first level is with no automation or vehicle control function. The second level is with one or two automation functions, and the third level with two or more functions for driving assistance. The fourth level is a limited self-driving functionality, but drivers still have the capability to take control while the fifth level is full-automation capability. The automated system of course depended on sensor detection ranges from which information beyond it cannot be processed. A five-level vehicle is then expected to have full control over various road, weather, and traffic conditions operating without any assistance of human drivers. Vehicles with the combination of connectivity and autonomous technology, known as Connected and Autonomous Vehicles (CAVs), can communicate with other CAVs and form platoons (i.e., CAVs can travel together as a group). The platoons of CAVs are designed to have shorter headways between each vehicle than headways between human-driven vehicles. A representative illustration is shown in the following figures where the four green cars in Figure 1 are a platoon of CAVs consisting of passenger cars, and likewise, Figure 2 is a platoon of CAVs consisting of trucks.

Figure 1: Example of a platoon of CAVs (passenger cars)

Figure 2: Example of a platoon of CAVs (trucks)

The implementations of CAVs applications (e.g., V2V/V2I communications and platoon of CAVs) have the potential to aid drivers who have difficulty travelling under complex traffic conditions or during adverse weather conditions (e.g., heavy fog / heavy rain, etc.). This will allow drivers to receive alerts of hazardous situations much earlier, providing more time to react and reduce the likelihood of crash occurrence. It can also influence the overall performance of roadway capacity and reduce overall travel time. With the formation of platoons with shorter headways, vehicles are expected to be influenced by simulating the driving behaviors of the CAVs. The reduced gaps between vehicles can then be occupied by other CAVs or HDVs thus increasing traffic capacity as well as making travel time relatively consistent and predictable. The vehicles are designed to be safer than human-driven vehicles expecting to perform with utilitarian motives. This safer and more accessible mobility options are for all users but especially for older adults and people with disabilities. Not only that, but aggressive drivers' behaviors can be mitigated by CAVs introduction through proper recommendations, as well as compensate for the driver's right of way infringement due to the CAVs' defensive features.

The projected benefits of CAVs outlined above are few of the many key incentives for drivers and passengers and even by-passing pedestrians. To ease a welcome and easy adaptation of the emerging innovative technology, many researchers have begun investigating the factors that affect the public acceptance of CAVs. Spreading the positive benefits of the vehicles and mitigating the potential negative consequences will be crucial in supporting CAVs. While they still remain to be an emerging transportation system, it is important that there be further studies regarding the interaction between HDVs and CAVs. Understanding the initial stages of CAV deployment will in effect popularize the advances of the vehicles' technology and more easily convince the public to utilize its impressive features. There must then be reliable data that can provide valuable insights regarding how drivers will interact with platoons of CAVs at various traffic and environmental conditions. Therefore, it is crucial to examine drivers' expectations, preferences, and behaviors toward multiple scenarios of CAVs. This study will allow researchers to gain further information on any potential shortcomings of the CAVs and suggest possible countermeasures that can assist transportation authorities to tailor their future policy and guidelines toward CAVs to better improve safety and mobility in its future introduction.

2. Literature Review

Extensive studies have been conducted investigating the world of connected vehicles, autonomous vehicles, and connected and autonomous vehicles. Beginning with exploring public perspectives, many scholars have attempted to measure people's preferences and expectations that will push them to use and purchase the vehicles. Much of the papers have revealed that these new mobility options are anticipated to be *better* than conventional vehicles because of their advanced technology. Still, much of the public remain hesitant in fully trusting CAVs until more relevant data can support the benefits of the vehicles as well as its conventionality in price and availability. Once the vehicles are incorporated into the traffic network, investigation on the change in driving decisions and behaviors have also been an interest for many researchers. The potential impact of the CAVs on drivers of conventional vehicles play a significant role in enhancing the capacity and safety of roadways. The setback for these studies is its lack in complex and diverse roadway scenarios that limit the analysis of driving behavior. On the other hand, other scholars have looked at the larger consequences of CAVs by looking at the traffic and safety impacts of the vehicles, researchers were able to isolate key problems of the current transportation system and take advantage of the CAVs' advanced technology. The anticipation is that HDVs will *mimic* the defensive and efficient behavior of the CAVs thus in large, enhancing roadway experience. With the already available extensive research done on CAVs, there still remains ample objectives for conducting studies and experiments from which novel information could hinder or propel the popularity of CAVs.

2.1 Public Perspective on the expected introduction of CAVs on the roadway

The beginning stages of the CAV study is understanding the perceived benefits and disadvantages of the innovative technology. From the perspective of drivers on automated vehicles to preferences and expectations of the CAV designs, many researchers have attempted to understand which factors contribute to acceptance and adoption of the vehicles. With the emergence of modern and improved advances in the vehicle, much of the public's trust rely on the utilitarian designs and irrefutable data to be the determining factors in convincing the people of its advantages. Below are examples for the studies that have explored the underlying variables that have been the cause for CAV approval or disapproval.

2.1.1 Older adults and their willingness to use semi and fully autonomous vehicles

The aging population's opinion on the advanced technology used in the transportation system is an important study to consider when evaluating the impact of automated vehicles (AVs) in society. In this regard, Hassan et al. (2021) examined factors that might influence older adults' willingness to use vehicles with various levels of automation (e.g., semi vs. fully autonomous vehicles; SAV/FAV). An online survey was conducted on 1000 individuals 65 of age and older in Southern Ontario, Canada. Factor Analysis and Structural Equation Modeling was used to investigate the explored data regarding the use of and knowledge about SAV and FAV. The Likert Scale was used to categorize the collected responses: importance, usage, and concerns about automated vehicles. The main outcomes were in favoritism towards SAV than FAV due to the still-available control of the vehicle during emergency. About half of the participants felt that there is insufficient testing on AVs, and 2/3 believed that the vehicle will not safely perform in all traffic and weather conditions. The results illustrate that more awareness and assistance programs are required to convince the older population of the AV's reliability and capability (Hassan et al., 2021).

2.1.2 Motorcyclists' and cyclists' perceptions of autonomous vehicle.

Vulnerable road users like motorcyclists and cyclists are of the main audiences those automated vehicles hope to aid. Trust in both the general and personal aspects are critical in ensuring the success of the AVs whose purpose is to eliminate the more-dangerous human error from the roadway. Pammer et al. (2021) conducted an online survey among a sample of motorcyclists and cyclists in which 92.3% hold a car license. Motorcyclists and cyclists were defined as those who use the corresponding transportation for more than twice a week. Descriptive statistics was used to address knowledge and experience with AV, perceived benefits and concerns, and general and personal trust and safety on autonomous vehicles. The Likert Scale was utilized in addition to correlation, regression, and qualitative analysis for a more thorough understanding of the studied variables. The study revealed that the acceptance and trust for AV could be more reflective on mistrust on human drivers rather than the vehicle's capabilities. It is believed that AVs will maintain a safer distance when sensing vulnerable road users, and therefore present itself at a higher advantage than human drivers. Another interesting result was that younger drivers believe AVs to be more utilitarian, programmed to behave in a way to always minimize casualties. There is no question that the general public believe automated vehicles benefit society, but mere belief in AVs is different from allowing autonomous vehicles to become a part of the roadway. Without adequate evidence and testing, AVs may face a tough time being acknowledged and utilized in its most competent capabilities (Pammer et al., 2021).

2.1.3 Trust in driverless cars: Investigating key factors influencing the adoption of driverless cars.

The use of autonomous vehicles in closed environments like college campuses, airports, parks, etc. may be important in the coming future. As a form of public transportation, AVs can serve as one of the efficient services readily available to targeted customers when needed. Kaur and Rampersad (2018) examined how students and employees may respond to the future use and adoption of AVs. An online survey was conducted among Flinders University students and staff who reside in the Tonsley Innovation Precinct, a closed setting on campus. About 101 responses were obtained from members of varying demographic backgrounds with no experience with driverless vehicles.

Descriptive analysis and confirmatory factor analysis was used to determine the variables and situations that respondents would be willing to use an AV inside and outside of campus. Performance expectation, privacy and security issues, and AV reliability were the proposed main influences that could affect implementation success. The findings also indicated that responders were more willing if they could use the AV for daily weekday commute to and from work or university (confirmed from 0.906 item loading of acceptance level). However, areas with high pedestrian activities and closed communities like college campuses have 0.781 and 0.667 loadings, respectively, thus indicating less likelihood of AV adoption in those scenarios (Kaur and Rampersad, 2018). The high-likely use of AV on weekday commuting supports AV popularity among university attendees who are tasked to have repetitive daily travel often left under the mercy of highway traffic. The hesitance of involving AVs in high pedestrian activities in a closed area can be swayed from past data indicating a reduction in accidents involving pedestrians when in the presence of AVs (Petrovića et al. 2020). Overall, this study serves as a starting point for further studying how university attendees are potential subjects in understanding the impact of Avs.

2.1.4 More extensive consequences of introducing AVs to society

In comparison to studies investigating immediate and direct consequences of autonomous vehicles, Kacperski et al. (2021) analyzed more extensive consequences of introducing AVs to society. A survey of 529 participants who have not had experiences with automated vehicles from France, Germany, United Kingdom, and Italy were first introduced to an AV-representative graphic image with descriptions of its function as a Level 5 or self-driving car. Factor analysis was used to organize and understand the set of data with loading factors above 0.70 as statistically significant. Environment sustainability, privacy, safety, and efficiency were the major consequences revealed from the conducted survey. It is generally understood that CAVs would improve environment sustainability and road safety but still felt uncertain about privacy protection and security. The role of efficiency is resulted to be neutral given that a third of the respondents felt the future introduction of CAVs would hinder and worsen traffic conditions while a third felt it would improve and better situations. Overall, in comparison to the other studied factors, participants consider efficiency as the least important when discussing the influence of CAVs and impose safety to be the most critical factor in influencing the acceptance for connected and autonomous vehicles. Still, it is argued that while it is favorable to maximize traffic safety, considering and accommodating the three other factors will be the most effective conclusion to CAV acceptance.

2.1.5 Eliciting preferences for adoption of fully automated vehicles

In a survey study done by Shabanpour et al. (2018) with 1013 responses in the metropolitan Chicago area from the Qualtrics online platform, preferences towards adoption of automated vehicles or driver-less vehicles are tied to best-work choice selection. Before the start of the survey, a neutral, informative message about autonomous systems was present to respondents from which expectations and opinions are collected based on least and most attractive features of the AV. From the data, usage and purchase of automated vehicles are linked to having less stressful driving experience, more productive time, and increase in safety especially from those who have had experience accidents caused by other human-driven vehicles. One of the main concerns that 58% of the respondents indicated is the imperfect performance of AVs when involved in unpredicted traffic situations as well as the pricing of the new vehicles (Shabanpour et al., 2018). Participants also expressed interest in the vehicles especially when longer daily routine travels dominate their day-to-day time and are open to saving as much time and energy as possible. From this, the idea of dedicated lanes also benefits potential customers as it is a given opportunity for avoiding traffic and its heterogenous flow and unpredictability. Still, AV failure and vehicle price are the most alarming concerns for the public as well as liability from AV accidents from which manufacturers and policy makers must fully comprehend and analyze. That study concluded that with the projected future of AVs and connected AVs, future studies should examine the mixed network of Human-Driven Vehicles and AVs/CAVs and how the conclusion can influence the likelihood that the emerging vehicle will be purchased and trusted.

2.2 Driving behavior of conventional vehicles to CAVs

Besides gaging the perspective of the public on the expected introduction of CAVs on the roadway, the driving behavior of conventional vehicles when influenced by the presence of connected and autonomous vehicles is an important issue that should be investigated. The incorporation of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications alone provide insight on a driver's operational decision as well as influence awareness and reaction time when warned about roadway conditions (Talepour et al., 2016). The incorporation of CAVs in mixed traffic network could potentially convince drivers to mimic the vehicle's short headway and safe driving characteristics. Still, these reported behaviors and decisions are limited in the intentions of the study and therefore does not offer information regarding more complex roadway scenarios.

2.2.1 Stated acceptance and behavioral responses of drivers towards innovative connected vehicle applications.

Many studies have analyzed societal acceptance of automated vehicles, but few have focused on behavioral response to connected and automated vehicles (CAVs). For example, Li et al. (2021) examined two applications of connected and autonomous vehicles to understand vehicle owners' reactions to predict CAV impact on improving traffic. A total of 650 complete survey responses were obtained from customers of automobile manufacturers. Chi-squared testing and logistic regression were used to statistically analyze the data. Lane Speed Monitoring (LSM) and High-Speed Differential Warning (HSDW) were the interests introduced in the survey through figures and description. LSM is an application used to determine traffic speed on each lane gathered from connected vehicles downstream traffic and report on congestion status. HSDW identifies where a large speed differential exists in the surrounding vehicles that can potentially cause hard breaking or collision. Both applications advise the driver to adjust speed or to change lane to avoid conflicts. The surveys revealed that 96% would change lane when advised from LSM and 84% would adjust speed according to HSDW advisory (Li et al., 2021). Both behavioral responses assessed the driver's decision and reaction when given safety warnings concerning traffic ahead. The findings revealed also those younger responders were more willing to immediately change lane for LSM and HSDW while older responders opted to get a second confirmation before changing lane for LSM and prefer to adjust speed in response to HSDW. This study, in addition to many others, have supported the concept that younger generations have a higher tendency to accept and submit to CAV technology while older generations remain to be skeptical. While having expected behavior given by surveys are a faster way of gauging responses, actual interactions testing LSM, HSDW, and other CAV applications can produce more accurate analysis.

2.2.2 Field Experiments on Longitudinal Characteristics of Human Driver Behavior Following an Autonomous Vehicle.

To overcome the shortcomings of surveys and micro-simulations, researchers have used real-life field experiments that offer current and comprehensive data. Zhao et al. (2020) were able to investigate driver performance when interacting with automated vehicles and put reasonings behind behaviors that can help convince trust on AVs. In this field experiment, 10 drivers were recruited, some are believers of AVs (3 drivers), some indifferent (5 drivers), and some skeptical (2 drivers). Because of the limited participants, they were diversely selected based on gender, experience, and familiarity with AV. The tested factor that defined their stance in supporting AVs are the gap measurement between an AV and a HV (i.e., human driven vehicles) when the lead vehicle is automated under two circumstances were AVs are identifiable and indifferentiable. The scene is an 800-meter straight road segment that limits testing more complex scenarios but offer a basic starting point for empirical data. The drivers were instructed to drive safely but as if late for work. They were not allowed to hit nor overtake the car but must follow without falling behind nor doing anything outside of driving. The obvious tell for doubt for AV is in correlation to the greater gap distance from a lead AV whether identifiable or not. The contrast is the smaller gap from those who trust AVs, knowing it is one or suspect it to be, because they are knowledgeable of its capabilities and precision in reducing travel time and increase in traffic safety (Zhao et al., 2020). The most important revelation from this study is that driver response and behavior, when around a connected and/or automated vehicle, is rooted in subjective trust of AV technology rather than the behavior difference from a human driver and computer driver. Investigating HV following AV behavior can be a breakthrough in understanding why C/AVs can become successful or a failure. The limitation of this paper is in its simple setting and limited driver number that can be further improved by cheaper simulations that can involve real-time human driver interaction.

2.2.3 The impact of a dedicated lane for connected and automated vehicles on the behaviour of drivers of manual vehicles.

Studies on mixed traffic conditions involving CAVs and HVs are one of the more interesting analyses of how drivers would behave and react when driving around CAVs. However, Rad et al. (2021) were more interested in understanding the impact of a dedicated lane for CAVs on surrounding HV. This study presented a comparison of CAV interacting with HV in any lane versus the presence of a CAV platoon on a dedicated lane and its effect on driving behavior. A number of 51 participants, 29 male and 22 females, were recruited from TU Delft campus in Netherlands. The investigation was in regard to HV driving behavior when adjacent to a CAV dedicated lane versus HV adaptation in a mixed traffic flow with moderate CAV penetration rate of 43%, and a base study with no CAV. Time headways and merging and diverging gaps were the factors scrutinized to see the change in behavior and driving styles of human drivers. A driving simulator with a dashboard mock-up, three screens to provide 180-degree vision, steering wheel, and pedal and blinker control was used as the experimental apparatus. The tested scenario consisted of a typical three-lane roadway with a speed limit of 100 KPH in the daytime with large curvature on and off ramps. The traffic flows were equal in all lanes and each case of base, mixed, and dedicated lane only differed necessarily. Under the base and mixed scenario, participants were not able to differentiate the two vehicles nor identify the platoon because the CAV was indistinguishable. With the dedicated lane, they were explicitly told of the fast lane exclusivity to

CAVs and of the presence of platoons. There was no presented difference between the base and mixed network due to the short platoon size and low exposure time, thus no behavior change was presented. However, under the dedicated lane scenario, the HV drivers were influenced by CAVs and found to be mimicking their driving behavior. Drivers more often accepted shorter gaps found to be common in CAVs, when changing lanes for on and off ramps, and followed vehicles more closely (Rad et al., 2021). One of the future interests presented in this study was to investigate whether educated drivers who know CAV capabilities would still show behavior adaptation when driving next to CAV platoons in comparison to uninformed knowledge of CAV abilities. It is also indicated that the limited observed behavior of base and mixed network difference could be overcome with more diverse CAV penetration rates and longer time exposure to CAVs.

2.2.4 Safety and experience of other drivers while interacting with automated vehicle platoons.

Under mixed traffic network with direct interaction between HV and AV, interaction characteristics in regard to the driver's experience and expectations with AVs were a venture that Aramrattana et al. (2021) investigated. Sixteen participants from Sweden were enlisted to participate in the driving simulation experiment where each participants ran eight 30-minute trials. There were 9 males and 7 females of an average age of 45 years old who have had a driving license for 2 years minimum and drives in the highway at least once a week. The simulation set up (i.e., SimIV driving simulator) had a driver interface with 210-degree view of 9 projectors that included a passenger cabin, and two side mirrors as well as rear-view mirror. The scenario consisted of an encounter with a platoon of five AV at a merging point in a two-lane highway released from the rightmost side of the highway. The platooning vehicles were at a constant speed of 102 km/h until the HV enters the rightmost lane from the right merging lane. The results indicated that HV drivers found it difficult to interact with AV in a merging highway and said to be mentally demanding and stressful. Experience and comfortability with merging highways also played a role in lessening the rough mental state of drivers even when in the presence of platoons. When tested under 15, 22.5, 30, ad 42.5-meter gaps between each AVs, drivers revealed that the smaller gaps felt unsafe and discomfortable and often resulted in a crash evident from having 1/3 of the 22.5-meter gap scenario experience accidents (Aramrattana et al., 2021). Even after increasing the gap, it did not change the driver's perceived comfort, safety, and ease of driving between platoon vehicles. To gain more insights on the mental condition of HV drivers, it was recommended to further study heart rate and brain wave pattern in merging scenarios with the presence of CAV platoons. Another interest was whether HV drivers would still force a cut in if AV gaps were under 15m or if the distance could be used to prevent a disruption on the AV platoon. This study suggested that further education of the public of AV driving characteristics could prepare human drivers and convince them that AVs are beneficial and safe.

2.3 Traffic and safety impacts of CAVs

The third searched out information regarding CAVs are its effect on traffic and safety conditions. From safety impact, to identifying *aggressive* drivers as well as accident reductions and traffic flow, there have been numerous research studies assessing the negative and positive consequences of CAVs. The most common source for data is often through surveys as seen predominantly in the *Perspective* section of the literature review, micro and macro simulations of roadway scenarios for the *Behavior* researched papers, and a combination of both for understanding *Traffic and safety*

Effect. Because of the limited data derived from actual interactions with CAVs or AVs as well as its field data in roadway conditions, the following studies note of its shortcomings but are confident in their analysis and deductive hypothesis.

2.3.1 Evaluating the safety impact of connected and autonomous vehicles on motorways.

With the introduction of connected and autonomous vehicles in the roadways, many simulations have evaluated CAV behavior in a mixed traffic network. The most prevalent circumstance to occur are the formations of CAV platoons. With this predictable CAV patterns, Papadoulis et al. (2019) mainly evaluated the safety effect and changes in traffic status due to the grouping CAVs. The source of this study is from VISSIM, a micro-simulation of traffic flow, used to design a 3-lane roadway 44.27 km long with merging and diverging areas of 8 on and off ramps without a roundabout. The concluded results were derived from 15 simulation runs that included traffic data from real world trips on the physical area of interest. The CAV algorithm in VISSIM was integrated with various sources like MATLAB and Surrogate Safety Assessment Model (SSAM) to include necessary data and proper safety evaluations, respectively. The observed maximum platoon length of 15+ CAVs could potentially impose a disturbance in traffic flow by blocking entrance and exit into the main highway (Papadoulis et al., 2019). The most impressive outcome from this study was the revelation of consistent and reliable travel time for all weekdays regardless of traffic conditions, thus proving that CAV, platoons specifically, are beneficial in vehicle trips. While micro-simulations are more accessible than real-world studies, it is not able to integrate human behavior into the design scenarios. This design was limited and not able to create differing traffic conditions nor accurately predict impact of CAV from the perspective of human drivers.

2.3.2 A driver behavior assessment and recommendation system for connected vehicles to produce safer driving environments through a "follow the leader" approach.

One of the many goals of connected vehicles are to provide safer travel in the highway as semi and fully automated vehicles. Besides being able to ride or drive automated vehicles and receiving informational warnings from its connection to other CAVs, the vehicles also serve as 'role models' for drivers. Because CAVs are designed to comply with highway laws and safe-driving behavior, utilizing this characteristic to guide aggressive drivers will add another benefit of CAVs according to the study conducted by Hong et al. (2020). The proposed systematic framework to identify the safest driving behavior provides recommendation to connect with the model vehicle and continue safe travel by avoiding typical aggressive driving performance. A safety score used to evaluate each travelling vehicle dataset that was derived from 2,736 anonymous drivers who drove a total of 50,000 trips. The simulation to test the system was done on 2500 vehicles modelled in Intelligent Driver Model (IDM). In order to make sense of the data, GMM-UBM machine learning was used to identify the target vehicle based on the universal behavior driving standards. Using the final model, micro-simulation of mixed traffic network with enabled scoring system was used to detect the safest neighboring driver. The involvement of human behavior was represented as a compliance rate that allows rejection of the system's recommendation whose number is derived from previous research regarding HSDW (Li et al., 2017). The 'follow the leader' approach could help mitigate dangerous human behaviors and eliminate human errors that often cause serious accidents in the highways (Hong et al., 2020). While the main objective of this paper was developing and testing a proposed system for connected vehicles, it does give a potential factor to be studied when evaluating actual human response to vehicle-to-vehicle (V2V) communication.

2.3.3 Traffic Accidents with Autonomous Vehicles: Type of Collisions, Manoeuvres and Errors of Conventional Vehicles' Drivers.

When dealing with human-driven vehicles or conventional vehicles and AVs in a mixed traffic network, studying types of traffic accidents involving each vehicle type can reveal just how much AVs have impacted traffic safety. In support, Petrovic et al. (2020) analyzed the types of traffic collisions, HV driver maneuvers, and driving errors in terms of distribution of crashes rather than its frequency. About 300 traffic accident sample with 247 accidents involving HVs only and 53 with AVs and HVs were collected from Californian Department of Moto vehicle. This publicly available data were gathered from a three-year period at 46 locations and categorized into 6 collision types, 8 maneuver types, and 9 HV driver errors. For statistical measure, the chi-square test of independence was combined with Yate's Correction for Continuity and Fisher's Exact Probability Test. The collision type distribution attributed 64.2% of rear-end crashes involved AVs while 28.3% to accidents involving conventional vehicles only. The main reasoning for such outcome is that HV drivers are not accustomed to AV driving style who indefinitely comply to traffic rules which other HV sometimes fail to do. The second most promising benefit of introducing AV into the roadways were a decrease in accidents involving pedestrians (5.7% of accidents with AV and 42.1% of HV only accidents). It was found that the 8 studied maneuver types had no significant difference in HV only and AV involved accidents due to minimal number of AVs in the studied area and that HV drivers did not take specific adjustments when involved with AVs. As for the errors of HV drivers, it was closely related to the rear-end accidents where HVs were following too closely. The most impressive consequence of having a defensive and slow-accelerating AV is that it is able to compensate for aggressive drivers' right of way violation (Petrovic et al., 2020). The main limitation of this study is its reliance on past data and therefore not able to generate other interesting data that could further support AVs. Analyzing driver's behavior that could potentially cause accidents is an interesting takeaway from this study. Understanding decisions and reasoning of conventional drivers when involved with AVs could improve communication and hopefully reduce more traffic accidents.

2.3.4 Impact of dedicated lanes for connected and autonomous vehicle on traffic flow throughput

When investigating the possible effect of CAVs on traffic flow, Ye and Yamamoto (2018) hypothesized that the full advantage of connected and autonomous vehicles may only be achieved through certain roadway conditions. In the near future where CAVs will soon dominate multi-lane highways (in this case, a three-lane highway), considerations for CAV dedicated lane, one or more, will be heavily scrutinized because of its extensive cost and limitations to conventional drivers. In this study, three proposals are analyzed: no CAV dedicated lane, one dedicated lane, and two CAV-only lane. The study uses flow rates as the determining factor of traffic flow indicative of travel efficiency and performance given that a higher flow rate corresponds to better driving performance and higher roadway capacity. It is revealed that with CAV penetration rate less than 10% will be a waste of dedicated lanes because it is underused while a penetration rate under 20% with a density exceeding 50 veh/km/lane will deem the lane(s) to be beneficial (Ye and Yamamoto, 2018). One of the foreseen uses of dedicated lanes is an increase in speed and therefore decrease in travel time with a projected speed of 120 km/h for CAVs and 95 km/h for the normal lanes (Ye and Yamamoto, 2018). When or if the idea of mixed traffic of CAVs and HVs are unfavorable, considerations for dedicated lanes have the potential of solving the shortcomings of integrated roadway conditions. Therefore, before the built of CAV dedicated lanes in roadways, it is important to understand how interacting drivers will react and behave when encountered a connected and autonomous vehicle as well as analyzing traffic capacity and relative flow.

3. Data

The data presented in the analysis was obtained from an online survey created in Qualtrics survey tool widely used for conducting survey research. Though simpler in comparison to other experiments, surveys serve as a powerful tool for gathering relevant information. In this study, individuals with valid driver's license were invited to participate in the survey. The survey has received Institutional Review Board (IRB) approval (IRBAM-21-0525) and is a part of the Transportation Consortium of South-Central States (Tran-SET) and DOT funded project.

3.1 Survey Content

The online survey was categorized in seven sections from which the first five sections are related to various roadway scenarios, the sixth for preference and willingness, and the seventh for participants demographics characteristics. Respondents were provided a condensed definition and illustration of CAVs prior to the commencement of the survey, identical to that found in the *Introduction section* discussed earlier. Participants were also given the opportunity to consult the definitions at any time during the survey. The five scenarios questioned driving decision under an on-ramp, off-ramp, overtaking on two-lane roads and multi-lane highways, and during critical weather conditions in a mixed traffic network where platoon of CAVs is present. The roadway scenarios placed each participant as a driver of a red car as shown in Figure 3 and asked them to report their responses if they must carry out certain tasks such as changing lanes, taking exits, overtaking, or given advisory information.

The first scenario investigated drivers' interaction with CAVs on on-ramp or acceleration lanes before merging with a highway. The scenario was explained to survey participants in which the survey's respondent and his/her representative vehicle (red car shown in Figure 3) are asked to leave the acceleration lane and merge with the highway when a platoon of CAVs is on the adjacent lane blocking immediate change in lane. Figure 3 illustrates the situation and was also shown to participants for clearer representation.

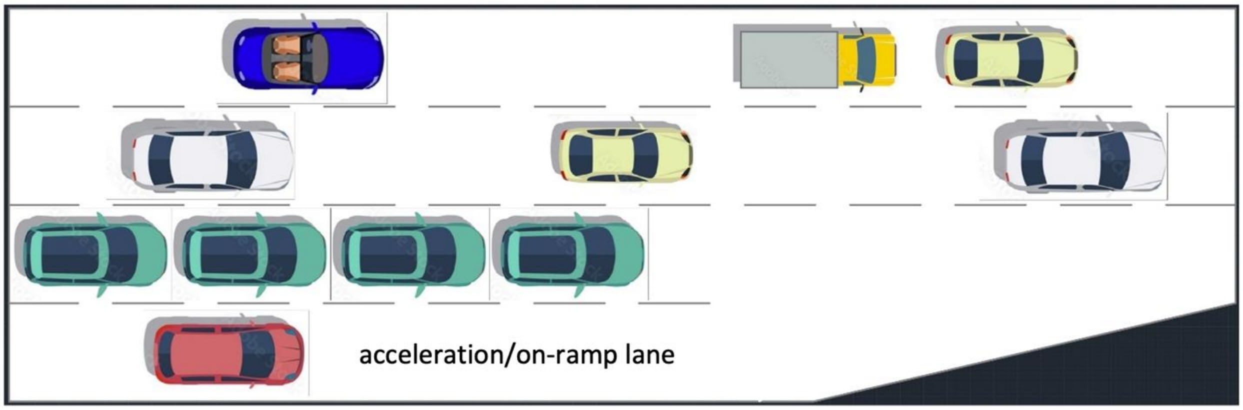

Figure 3: Scenario 1 – On-Ramp with CAVs consisting of passenger cars

Driving decision, preferred vehicle gap, comfortability, and involvement in accidents were the topics questioned for each scenario. If available, a defensive CAV maneuvering intended to help drivers was suggested and participants were asked if their comfortability level or preferences would change. For scenario one, it was proposed that if the CAVs were able to detect the merging vehicle and allow the drivers to break the platoon for easier change in lane, the driver was asked if they would feel safer leaving the acceleration lane or if they would rather have only HDVs on the adjacent lanes of on-ramp/acceleration lanes. When appropriate, the same scenarios were presented but for a platoon of truck CAVs as shown in Figure 4.

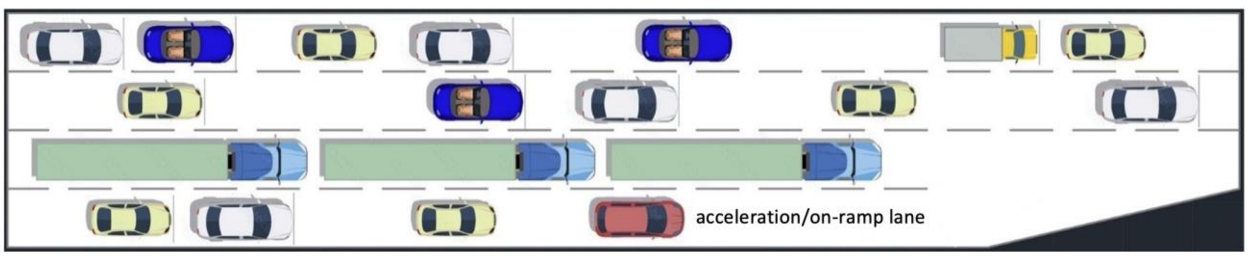

Figure 4: Scenario 1 – On-Ramp with CAVs consisting of trucks

The second scenario acted out the same situation instead for off-ramps or for highway exits (i.e., LSU Exit, in which the drivers' route (red car shown in Figures 5 and 6) requires taking the exit. In this setting, the driver's decision carried heavier consequences as there is no safe *space* from which the driving vehicle can stop and wait for the platoon of CAVs unlike that for the on-ramp scenario where drivers' have the option to safely wait at the ending acceleration lane. Instead, the drivers either have to potentially miss the exit or accelerate to overpass the platoon if breaking the platoon is not their preferred decision.

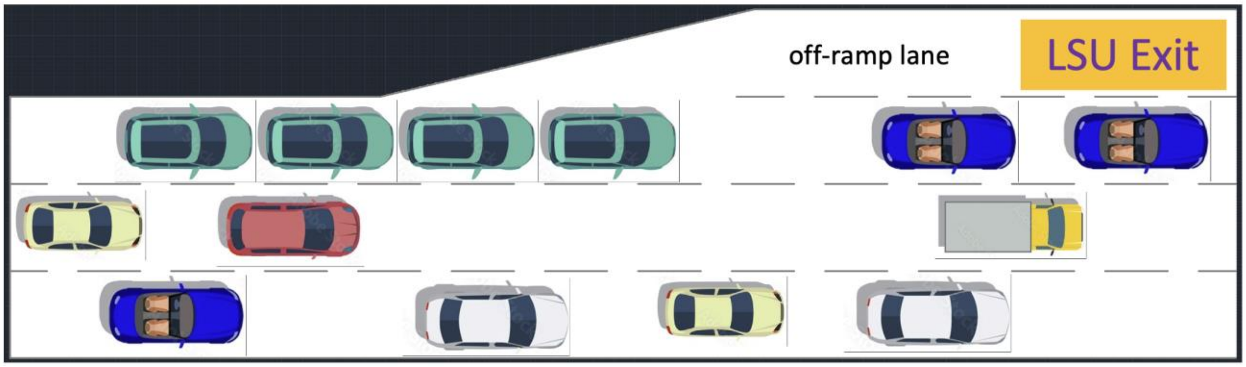

Figure 5: Scenario 2 – Off-Ramp with CAVs consisting of passenger cars

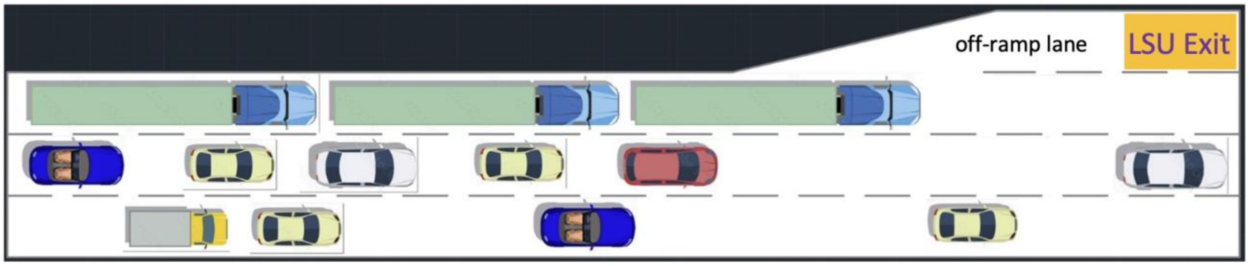

Figure 6: Scenario 2 – Off-Ramp with CAVs consisting of trucks

For scenario three, a driver's preference in overtaking in two-way two-lane roads were questioned when a lead platoon of CAVs is preventing the driver to travel at a desired speed (i.e., Figure 7). In this scenario, the drivers were questioned if the driver of the red car shown in Figure 7 was going to pass and overtake each vehicle of CAVs platoon or attempt to pass the entire platoon in one attempt or settle in driving behind the CAVs. If given the only choice of having a platoon of CAVs as the lead vehicles, speed ranges of the CAVs were optioned from which the participant selects which speed they would be satisfied driving behind the platoon on two-lane roads. No same scenario was presented for truck CAVs as it is already unlikely that drivers would overtake a platoon of trucks on two-lane roads. Still, a question regarding driving comfortability as well as CAV detection for easier passing and overtaking was also proposed along with past accident history regarding overtaking on two-lane roads.

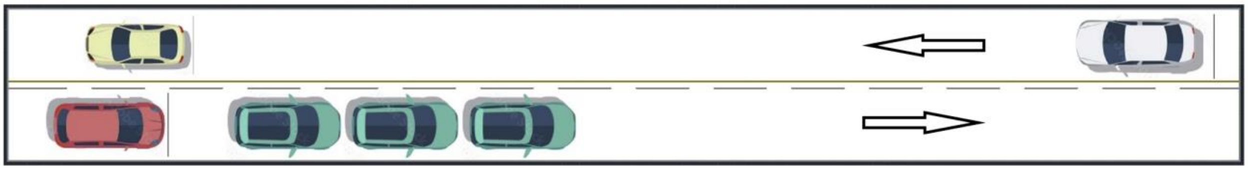

Figure 7: Scenario 3 – Overtaking a platoon of CAVs on 2-Lane Roads

Scenario 4 again investigated overtaking maneuvers but on multi-lane highways where drivers can decide to follow behind the platoon of CAVs or change lanes. Figure 8 and Figure 9 show the setting and whose main objective was understanding in which situation or speed range would a driver remain behind the platoon of CAVs consisting of passenger cars or trucks.

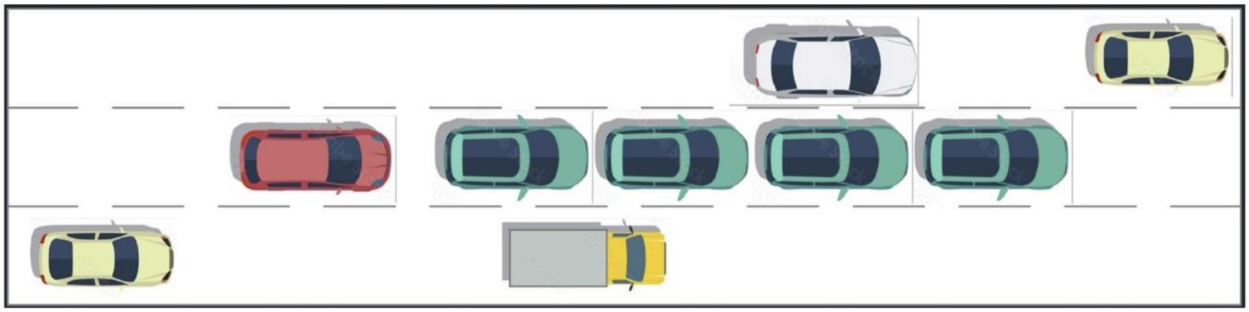

Figure 8: Scenario 4 – Overtaking on Multi-Lane Highways with CAVs consisting of passenger cars

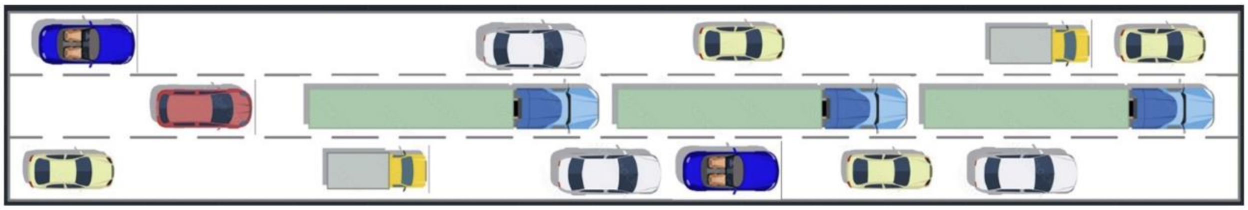

Figure 9: Scenario 4 – Overtaking on Multi-Lane Highways with CAVs consisting of trucks

The last scenario questioned is regarding a driver's reaction to the presence of CAVs platoon under critical weather condition. Figure 10 and Figure 11 represent the set-up from which participants are asked if a platoon of CAVs consisting of passenger cars or trucks makes an impact in their behavior. It was also suggested that if an alert is given to the driver advising them to follow behind the platoon, a driver is given the option to heed or ignore the proposal. This scenario also takes advantage of connected vehicle technology in communication. It presents the capabilities of CAVs in attaining and receiving relevant information regarding road conditions that could positively affect traffic safety and operation.

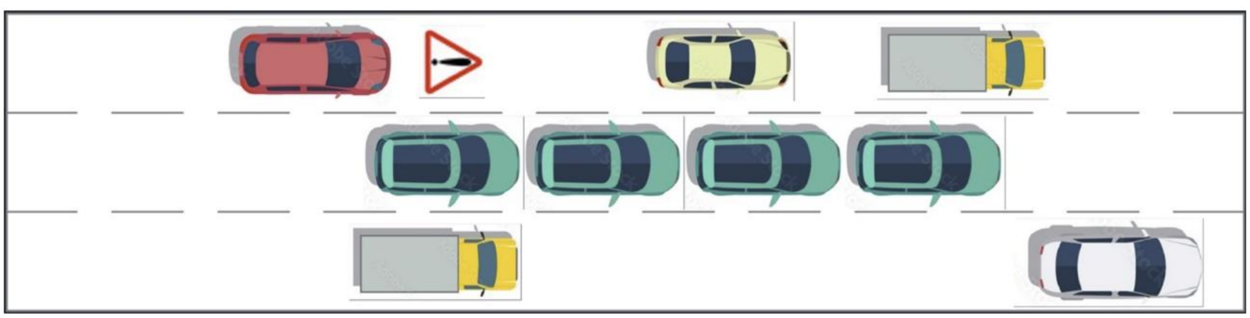

Figure 10: Scenario 5 – Critical Weather Conditions with a platoon of CAVs consisting of passenger cars

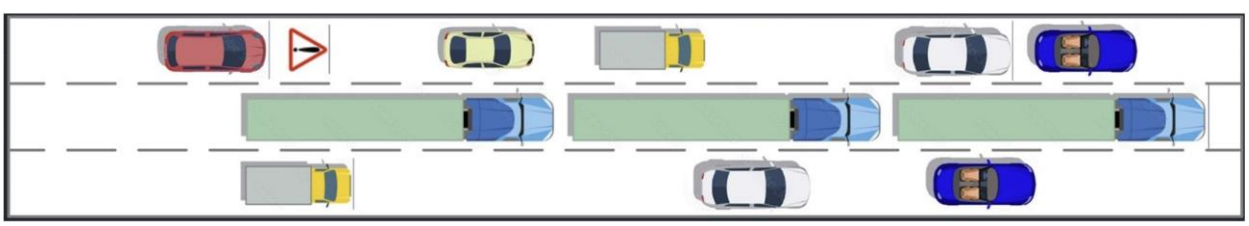

Figure 11: Scenario 5 – Critical Weather Conditions with a platoon of CAVs consisting of trucks

The sixth section deals with the drivers' preferences and willingness to imitate CAV driving behavior as well as intentions on purchasing a vehicle with CAV capabilities. The last section examined the demographics characteristics of the participants (e.g., age, gender, education, income, etc.). The focus of the analysis then relies on the first five sections using the latter two as supporting data.

3.2 Survey Responses

A total of 120 full responses from 175 invited individuals made up the sample size. Table 1 summarizes the demographics of the participants. A count of 47% female and 53% male is fairly balanced, and the age distribution is moderately scattered but with the older adults minimally represented. The educational background of the respondents majorly attained a bachelor's degree, master's degree, and high school diploma with the rest of the education category getting less than 10% of the survey participants. Other relevant characteristics is outlined in the aforementioned table from which it can be gathered that about 68% of the survey respondents have more than 5 years of experience.

Table 1: Demographic Characteristics of Survey Respondents

Variable	Categories	Survey Participants (N = 120)	
		Frequency	Percentages
Gender	Male	64	53 %
	Female	56	47 %
Age	16 - 24	46	38 %
	25 - 40	25	21 %
	41 - 55	32	27 %
	55 - 65	12	10 %
	65 +	5	4 %
Education	No Certification	9	8 %
	High School Diploma	24	20 %
	College Diploma	11	9 %
	Associate Degree	6	5 %
	Bachelor's Degree	36	30 %
	Master's Degree	24	20 %
	Doctorate Degree	4	3 %
	Other	6	5 %
Employment	Unemployed	12	10 %
	Employed	99	83 %
	Retired	4	3 %
	Other	5	4 %
Household Income	Less than 20,000	19	16 %
	20,000 - 49,999	30	25 %
	50,000 – 89,999	38	32 %
	Above 90,000	33	28 %

Residency	Urban Area	40	33 %
	Suburban Area	51	43 %
	Rural Area	29	24 %
Number of Vehicles	0	9	8 %
	1	61	51 %
	2	27	23 %
	3 +	23	19 %
Driving Experience	Less than 2 years	14	12 %
	2 – 5 years	24	20 %
	More than 5 years	82	68 %

4. Methodology

The analysis of the data begins with descriptive analytics, from which the following representative figures give summary results in the form of frequency tables for the five tested scenarios as well as the preference and willingness section of the survey. The two-way association analysis test was initially performed on specified dependent variables in the form of questions versus the remainder of the inquiries using the SAS analytic statistical tool. The P-values for significant relationships between the dependent and independent variables were chosen with a 90% confidence level. The linked associations were then subjected to a logistic regression model, which yielded four reliable models, which were discussed and examined afterwards.

5. Results

Descriptive and multivariate analysis was used to analyze the survey data from the 120 respondents. The survey content question and answers were transfigured into frequency tables and independent and dependent variables later to be used for logistic regression model. The result section intends to only present the gathered data with no breakdown and evaluation of the trends and relationships found in the survey. Instead, the uninterpreted statistics and findings found in the following figures provide a chance for distinctive understanding of the results that can differ from the later-found discussion section to highlight the multifaceted characteristics of researching the impact and influence of connected and autonomous vehicles.

5.1 Descriptive Analysis

After six weeks of gathering data for the survey, descriptive analysis in the form of bar charts shown in the following figures in this section will reveal drivers' behavior, preferences, and willingness in the presence of CAVs in multiple roadway scenarios. Each scenario's description will correspond heavily with *Section 3. Data* to illustrate the stories behind each responses' choice selection. It should be noted that only the survey frequencies are shown in the report to showcase the general attitude and decisions of participants. The goal of this section is then to present a summarized findings that can reveal interesting information about drivers' interactions with CAVs.

5.1.1 Scenario 1: Drivers' reactions and preferences towards CAVs on On-Ramp Areas

After the respondents were introduced to the definition of the CAVs, they were first questioned about their behaviour and preferences if they have to merge unto a highway in the presence of CAVS on on-ramp areas. Figures 3 and 4 in *Section 3.1 Survey Content* illustrated the image and story behind the following results for Figures 1.1 through Figure 1.4. As shown in Figure 1.1, it was found that almost two thirds of the survey's participants (64%) would wait for the platoons of CAVs to clear from the adjacent lane that are blocking immediate change in lane to merge onto the highway even if it meant stopping the vehicle completely at the end of the acceleration lane. The second likely decision would be to go faster and overtake the platoon to change lanes with 23% of the participants choosing this driving behavior rather than breaking the platoon to merge on to the highway (13%). As shown in Figure 1.2, about half of survey's respondents (49%) would prefer a vehicle gap of at least two vehicle-length away between the vehicles in the CAVs platoon for them to consider breaking the platoon to enter the main highway. A preference of three or more vehicle-length and one vehicle-length away received almost the same percentage of choice at 22% and 21% respectively. A small percent of drivers (8%) indicated that they have no CAV gap preference as they feel that they are able to break the platoon of CAVs with any given vehicle gap. When talking about drivers' comfortability in using the on-ramp lane in the presence of CAVs, about 23% of drivers indicated that they would feel uncomfortable or very uncomfortable as illustrated in Figure 1.3. The last asked question is in Figure 1.4 was about drivers' feeling of safety with the presence of a platoon of CAVs if the advanced vehicles are able to detect the merging cars and increase the gap within the platoon for easier entering onto the highway. From this question, it is revealed that most of the drivers (73%) would feel safe if the CAVs were able to help in merging while 18% of the drivers preferred to not have CAVs on the adjacent lanes of on-ramp lanes and few still did not feel safe at 8% participant choice.

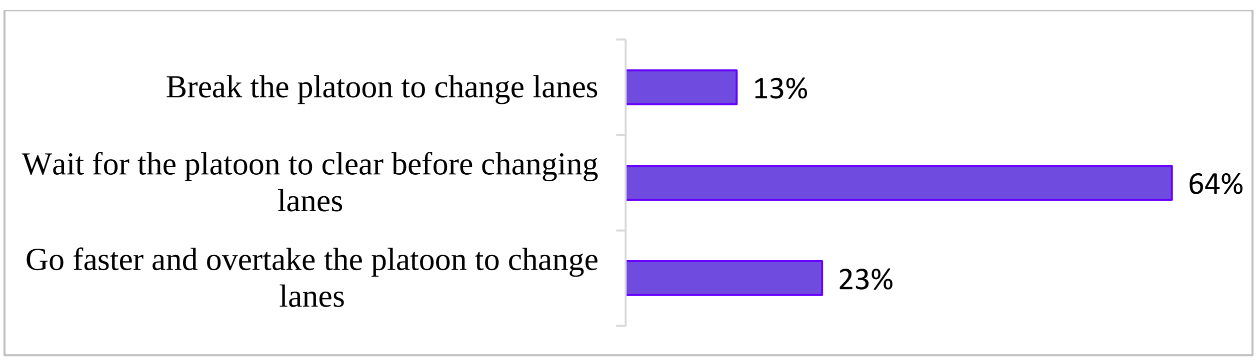

Figure 1.1 Drivers' behavior when merging onto the highway with a platoon of CAVs on the adjacent lane blocking immediate change in lane

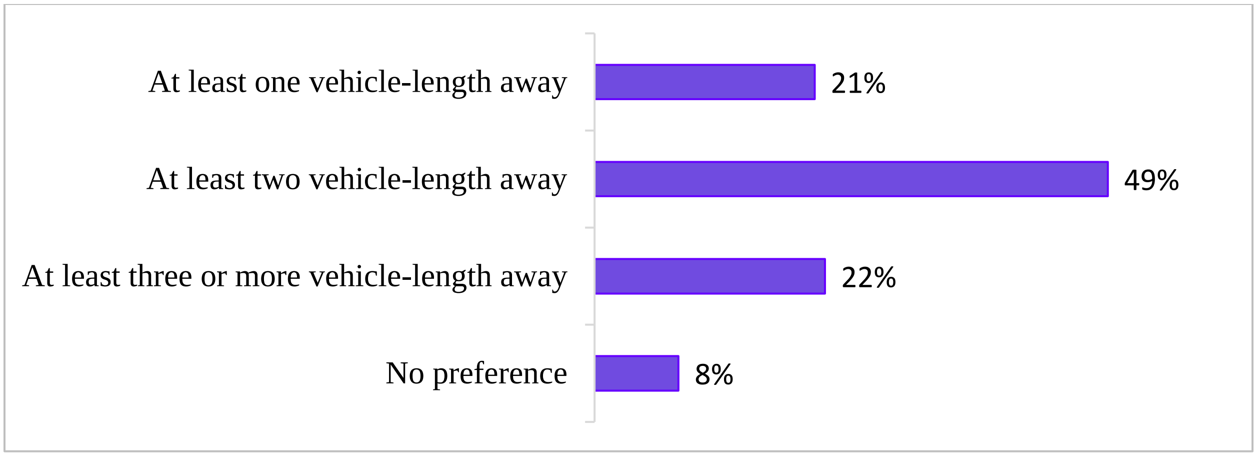

Figure 1.2 Drivers' preferred vehicle gap between the CAVs if they must break the platoon to enter the main highway

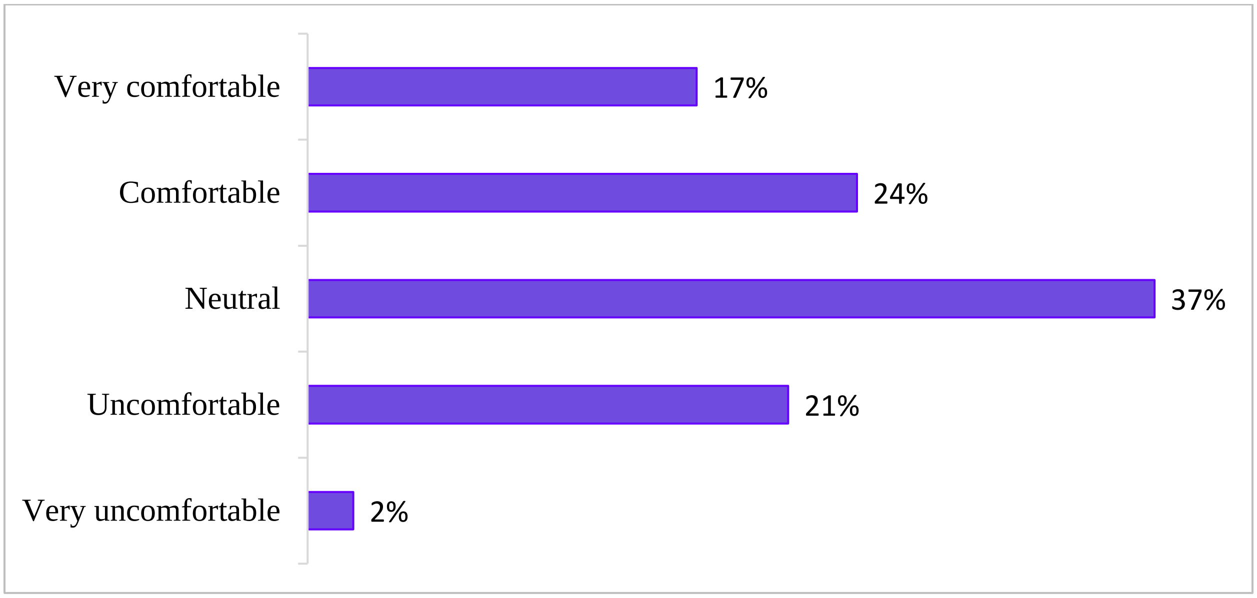

Figure 1.3 Drivers' comfortability in using the on-ramp lane in the presence of CAVs

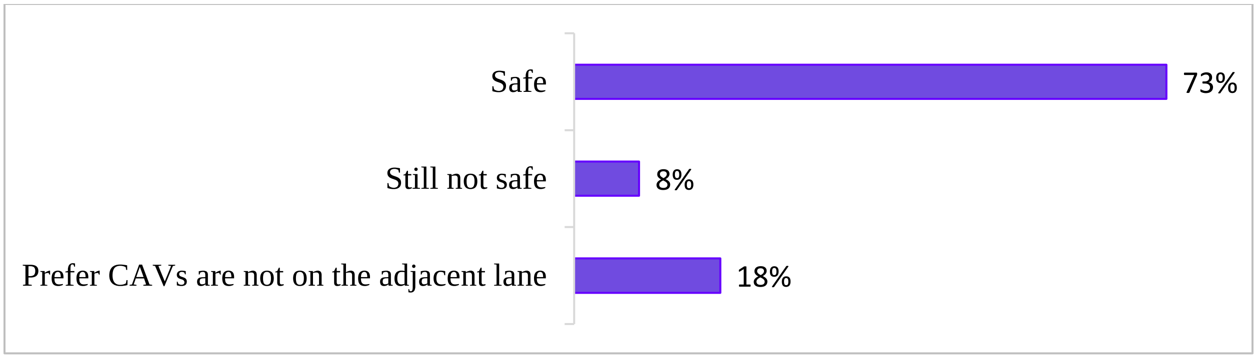

Figure 1.4 Drivers' feeling of safety with a platoon of CAVs on the adjacent lane that are able to detect the merging cars and increase the gap within the platoon for easier entering onto the highway

To investigate the influence of truck CAVs rather than passenger CAVs, Figure 4 in *Section 3.1 Survey Content* introduces the same scenario from Figure 3 of the abovementioned section. Figures 1.5 and Figure 1.6 address drivers' behaviors and preferences while merging with a highway in the presence of CAVs platoon consisting of trucks on the adjacent lane while Figure 1.7 questioned past involvement in traffic accidents at on-ramp lanes. It was found that about half (49%) would still wait for the platoon of truck CAVs to clear before changing lanes than choose to go faster and overtake the truck CAVs (33%) or break the platoon (18%). This pattern is similar to that of Figure 1.1 for passenger CAVs. For preferred vehicle gap, three or more vehicle-length and two vehicle length were the more likely choices at 37% and 36% participant choices respectively. Having one vehicle-length is selected by 21% of the respondents while 7% indicated no preference in platoon gaps of truck CAVs as they are able to navigate breaking the platoon to enter the main highway. As shown in Figure 1.7, the results revealed that majority of the drivers (94%) have not been involved in an accident due to lane-changing maneuvers at on-ramp lanes of a highway in the last three years but only 6% of participants in this study indicated that they have been involved in traffic accidents.

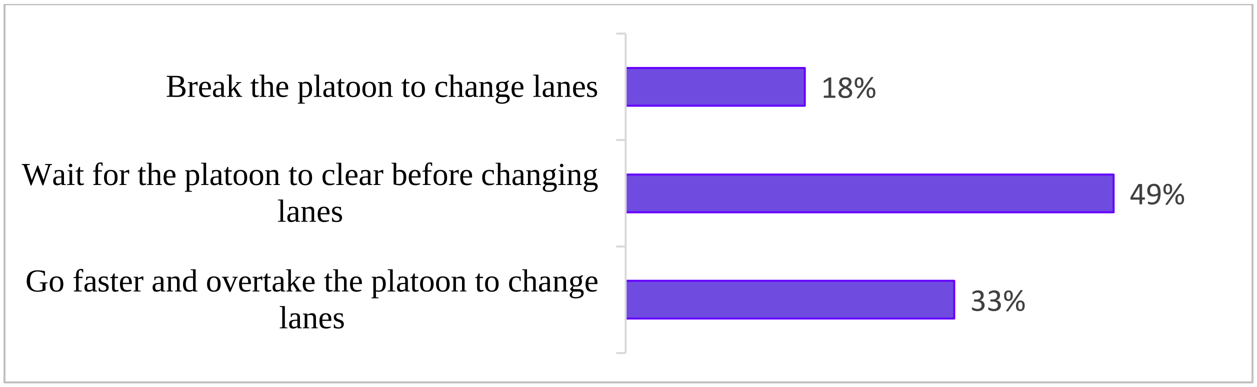

Figure 1.5 Drivers' behavior when merging onto the highway with a platoon of truck CAVs on the adjacent lane blocking immediate change in lane

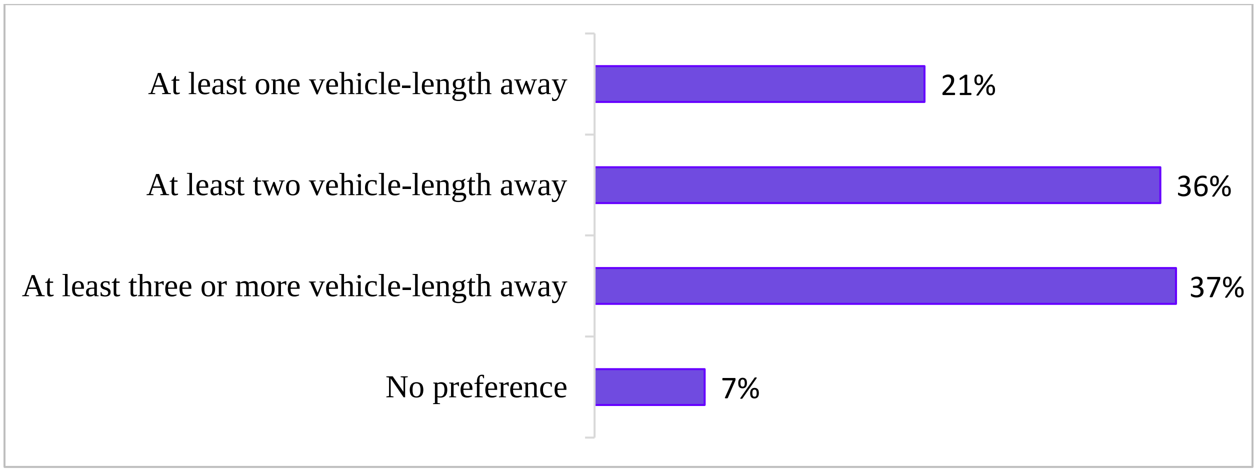

Figure 1.6 Drivers' preferred vehicle gap between the truck CAVs if they must break the platoon to enter the main highway

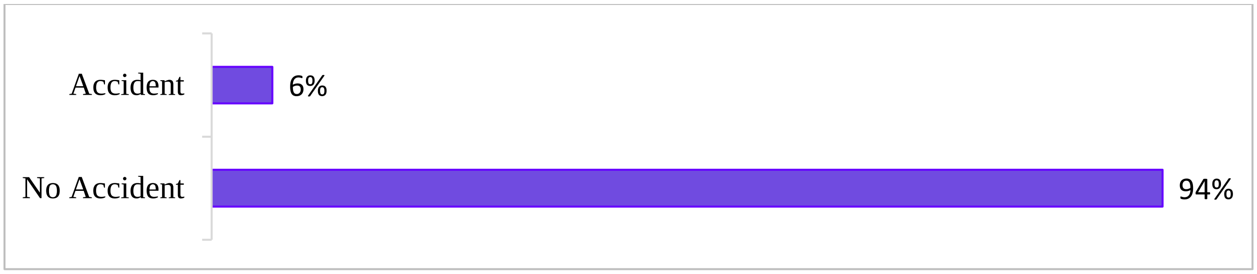

Figure 1.7 Drivers' involvement in an accident due to lane-changing maneuvers at on-ramp lanes of a highway in the last 3 years

5.1.2 Scenario 2: Drivers' reactions and preferences towards CAVs on Off-Ramp Areas

The format of the questions on Scenario 2 of CAVs on off-ramp areas is like Scenario 1 as shown in Figure 5 and Figure 6 from *Section 3.1 Survey Content* demonstrating the provided images and storyline. As seen in Figure 2.1, about half (56%) of survey respondents once again selected to wait for the platoon to clear before changing lanes to exit the highway even if they could miss the exit, but 33% of the drivers reported that they would break the CAVs platoon (consisting of passenger cars) to take the exit rather than going faster and overtaking the CAVs which the other 12% selected to do. In terms of preferred vehicle gap between the vehicles of CAVs platoon, half of the drivers (53%) claimed that they prefer to at least have two vehicle-length distance if they must break the platoon to exit the main highway. The second-most selected preference is one vehicle-length at 24% with 13% and 11% for three or more vehicle-length gap and no preference for platoon headways respectively as show in Figure 2.2. About 27% of drivers felt uncomfortable or very uncomfortable to change lane in order to exit the highway in the presence of CAVs as illustrated in Figure 2.3. In terms of drivers' feeling of safety in exiting from the main highway if the CAVs platoon were able to detect the adjacent cars at off-ramp areas and increase the headway between the vehicles in the CAVs platoon for easier driving maneuver, most participants (77%) felt safe in the CAVs' presence. An equal percentage of 12% drivers still did not feel safe and prefer to not have CAVs drive on adjacent lanes of exiting off-ramps showcased in Figure 2.4.

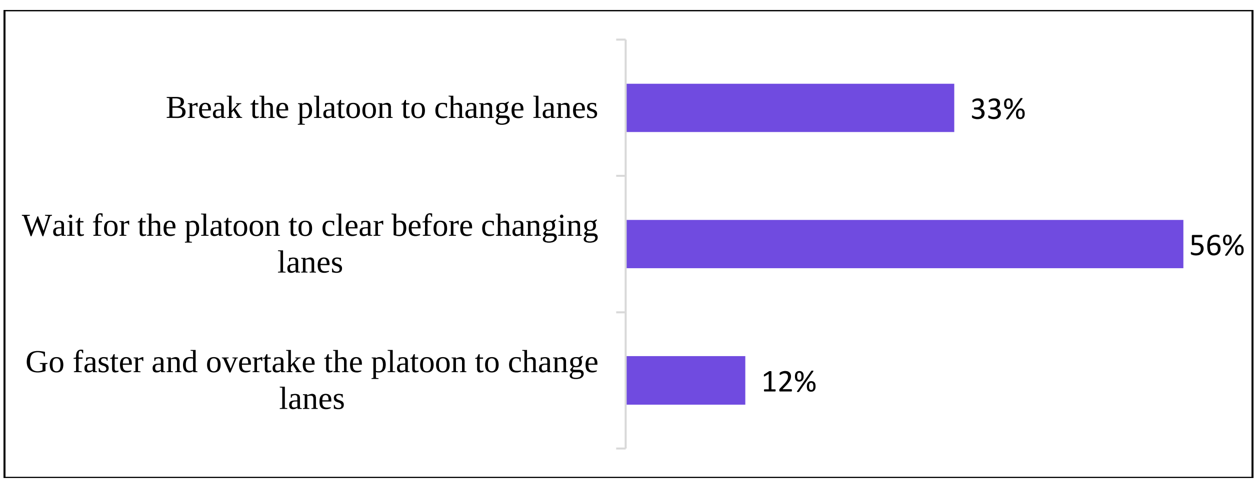

Figure 2.1 Drivers' behavior when taking a highway exit with a platoon of CAVs on the adjacent lane blocking immediate change in lane

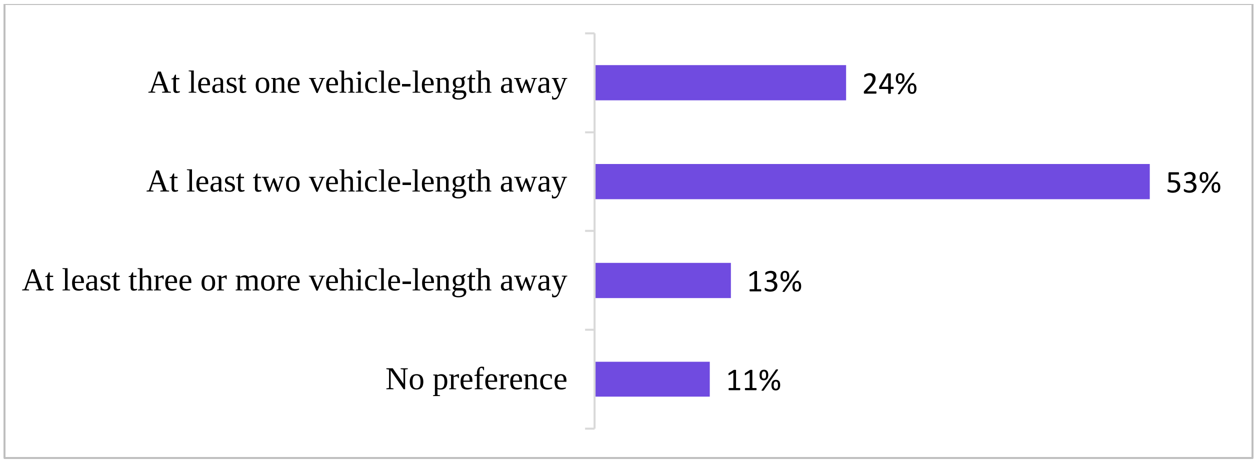

Figure 2.2 Drivers' preferred vehicle gap between the CAVs if they must break the platoon to exit the main highway

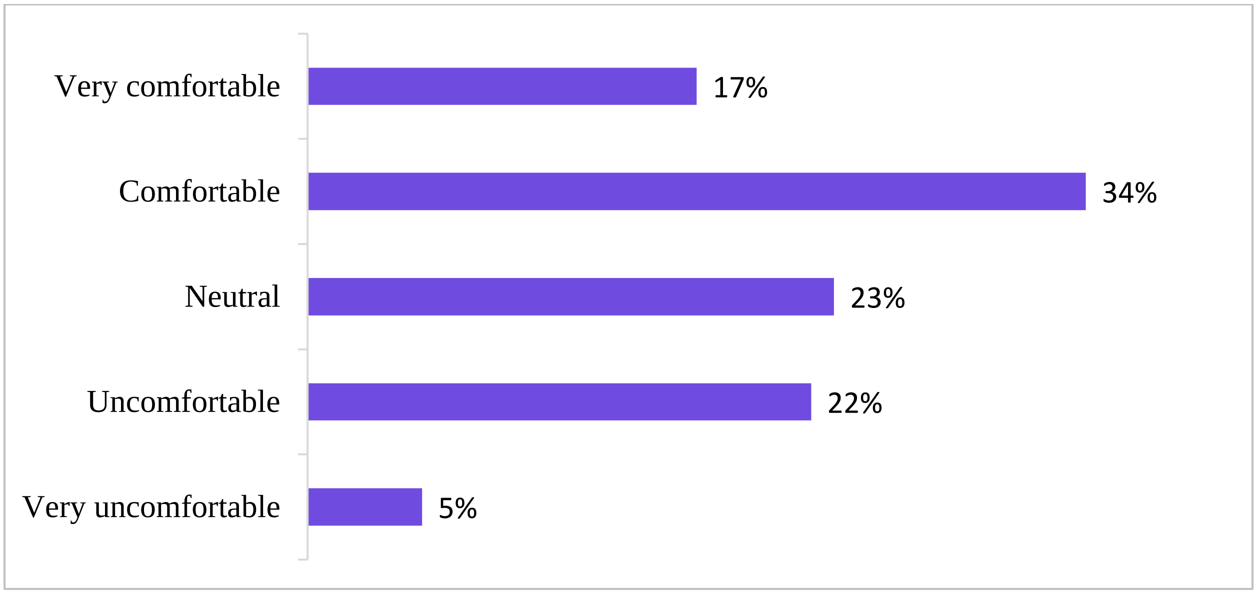

Figure 2.3 Drivers' comfortability in entering the off-ramp lane in the presence of CAVs

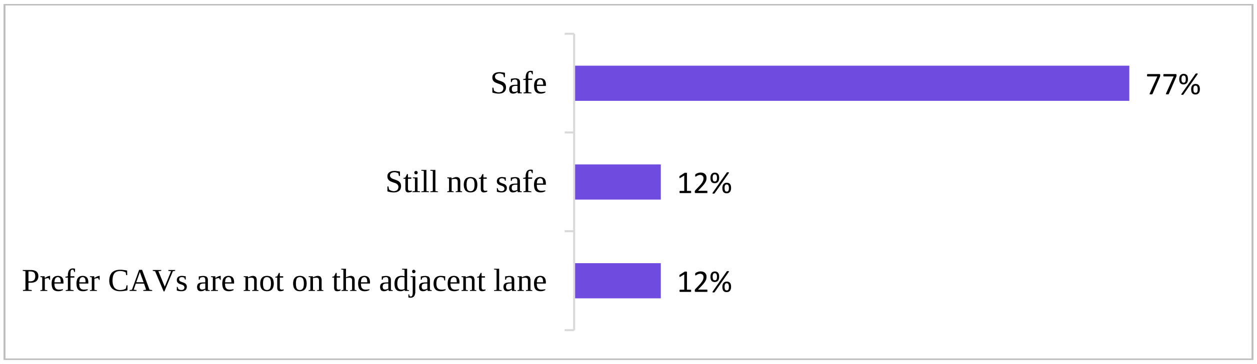

Figure 2.4 Drivers' feeling of safety with a platoon of CAVs on the adjacent lane that are able to detect the merging cars and increase the gap within the platoon for easier exiting from the highway

Similarly, the following two figures (Figure 5 and Figure 6) investigated drivers' behavior with platoon of truck CAVs where Figure 2.5 revealed that over half (60%) of the respondents would wait for the platoon to clear before changing lanes. About 21% choose to go faster to overtake the platoon to take the exit and 19% opted to break the platoon instead so that they can immediately switch lanes to leave the main highway. Descendingly, drivers preferred to have at least two vehicle-length gaps between the truck CAVs to break the platoon (39%), at least three or more vehicle-length away (32%), then one vehicle-length away (22%), and lastly no preferred vehicle gap (8%) as they feel confident in being able to exit the main highway in the presence of truck CAVs (Figure 2.6). The last question in this scenario (Figure 2.7) was about drivers' involvement in traffic accidents at off-ramp areas from which a majority of 93% revealed to not have had an accident and with 7% having experienced such.

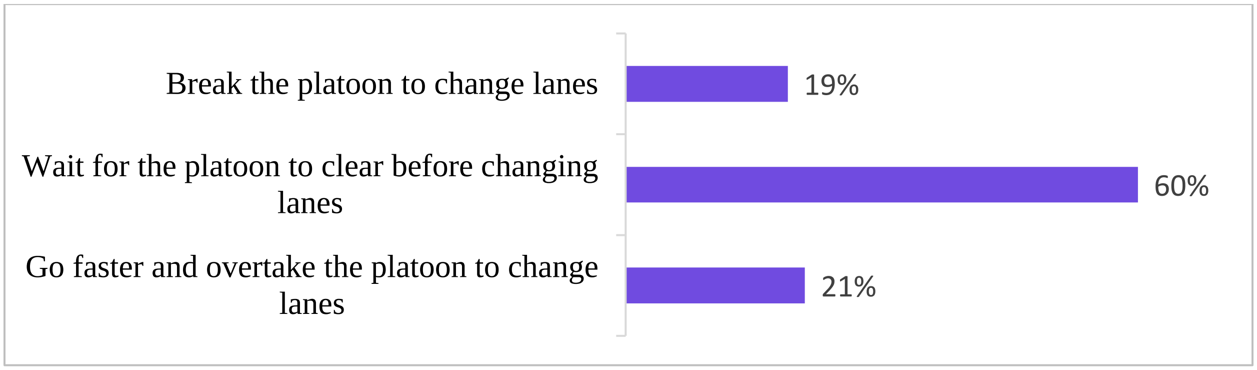

Figure 2.5 Drivers' behavior when taking a highway exit with a platoon of truck CAVs on the adjacent lane blocking immediate change in lane

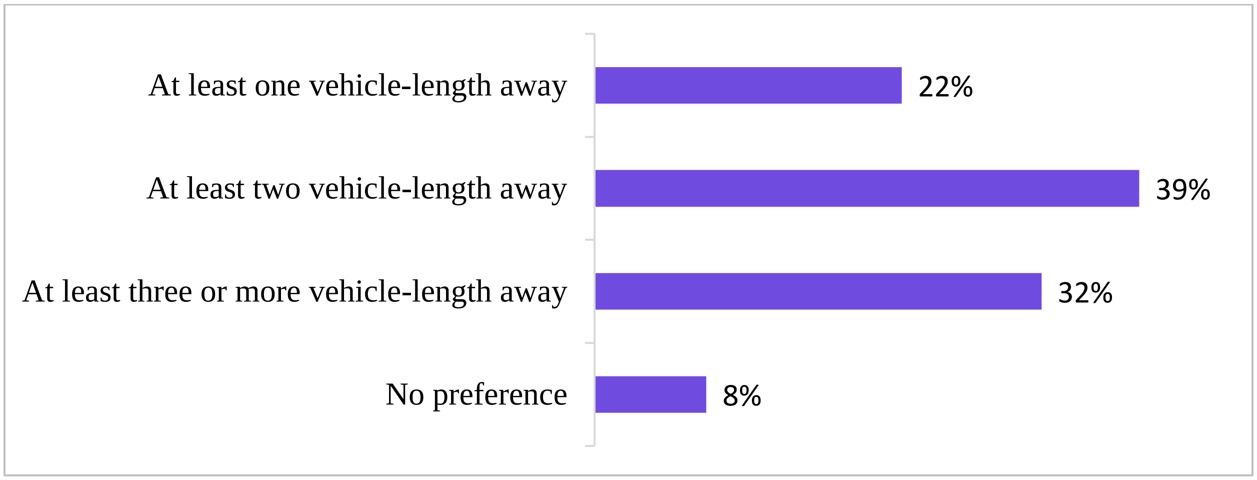

Figure 2.6 Drivers' preferred vehicle gap between the truck CAVs if they must break the platoon to exit the main highway

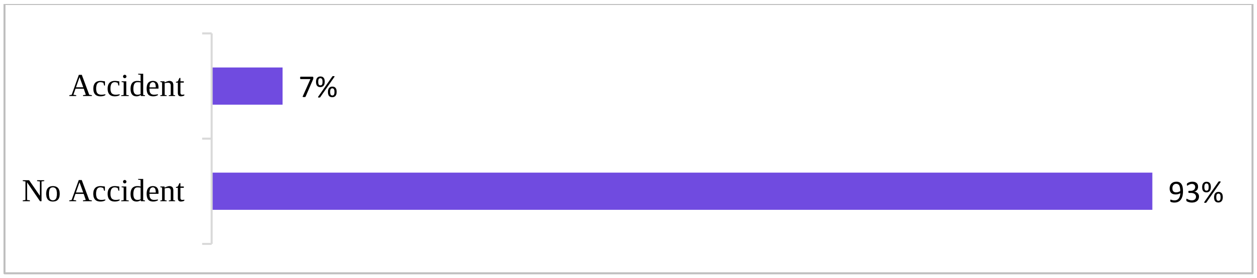

Figure 2.7 Drivers' involvement in an accident due to lane-changing maneuvers towards off-ramp lanes of a highway in the last 3 years

5.1.3 Scenario 3: Drivers' reactions and preferences towards CAVs on 2-Way 2-Lane Roads

As shown in Figure 7, *Section 3.1 Survey Content,* Scenario 3 discusses drivers' reactions and preferences towards interacting with CAVs on 2-way 2-lane roads. The findings revealed that two thirds of the drivers (63%) stated that they would not overtake the leading platoon of CAVs on a two-way two-lane road, but a quarter (26%) would attempt to overtake and pass the entire platoon in one maneuver while 12% would overtake and pass but with one vehicle of a CAV platoon at a time as illustrated in Figure 3.1. When questioned about the drivers' preferred speed of the CAVs in order for them to continue driving behind the platoon, similar percentages of 43% and 42% would do so if the CAVs were travelling at least 5-10 mph above the speed limit and at the speed limit respectively. The remainder would follow at 10-15 mph above the speed limit (12%) and 3% of the drivers would follow if CAVs travel over 15 mph above the speed limit as seen in Figure 3.2. In terms of comfortability in overtaking a platoon of CAVs on two-way two-lane roadway, the results indicated that about 41% of survey's respondents reported that the would feel uncomfortable and very uncomfortable as showcased in Figure 3.3. The feeling of safety in overtaking if the CAVs can increase their headways for easier passing after detecting the drivers' maneuvers rendered 46% feeling safe, 28% prefer that CAVs do not form platoons in 2-way 2-lane roads, and 18% still not feeling safe regardless of the CAVs' aid in overtaking with a few of 8% prefer to have CAVs not use 2-way 2-lane roads in their route (Figure 3.4). Like the other similar questions, the majority of the participants (97%) have not been involved in overtaking related accidents on 2-way 2-lane roads in the last 3 years with the rest (3%) having had accidents (Figure 3.5).

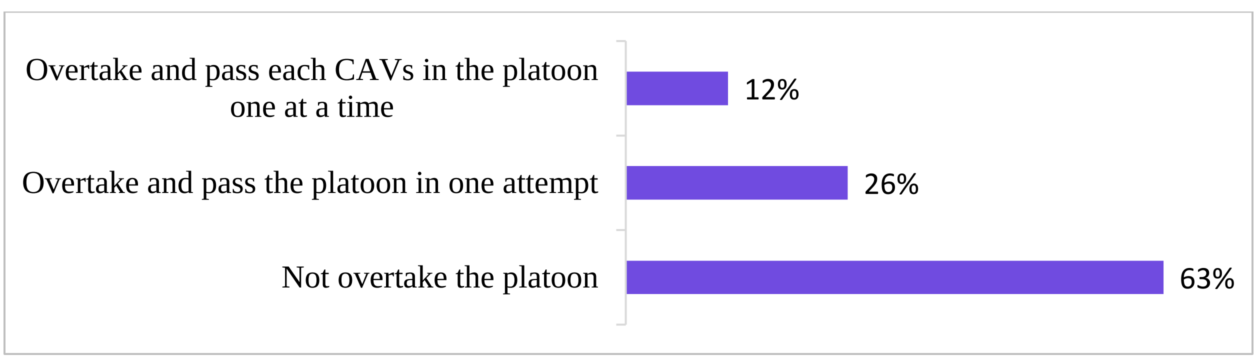

Figure 3.1 Drivers' behavior when overtaking and passing a platoon of CAVs on a 2-way 2-lane road

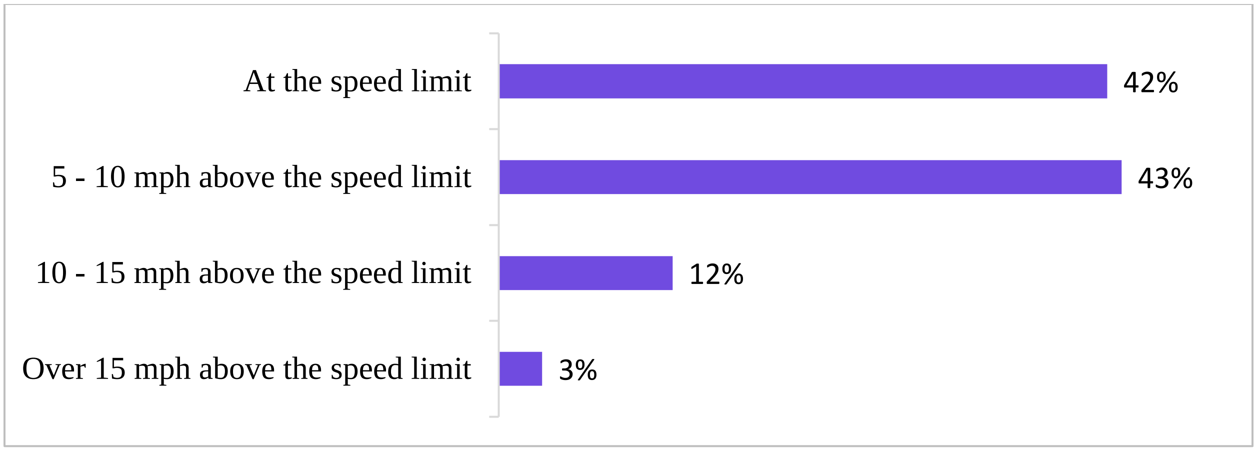

Figure 3.2 Drivers' preferred speed of the CAVs to continue driving behind the platoon on a 2-way 2-lane road

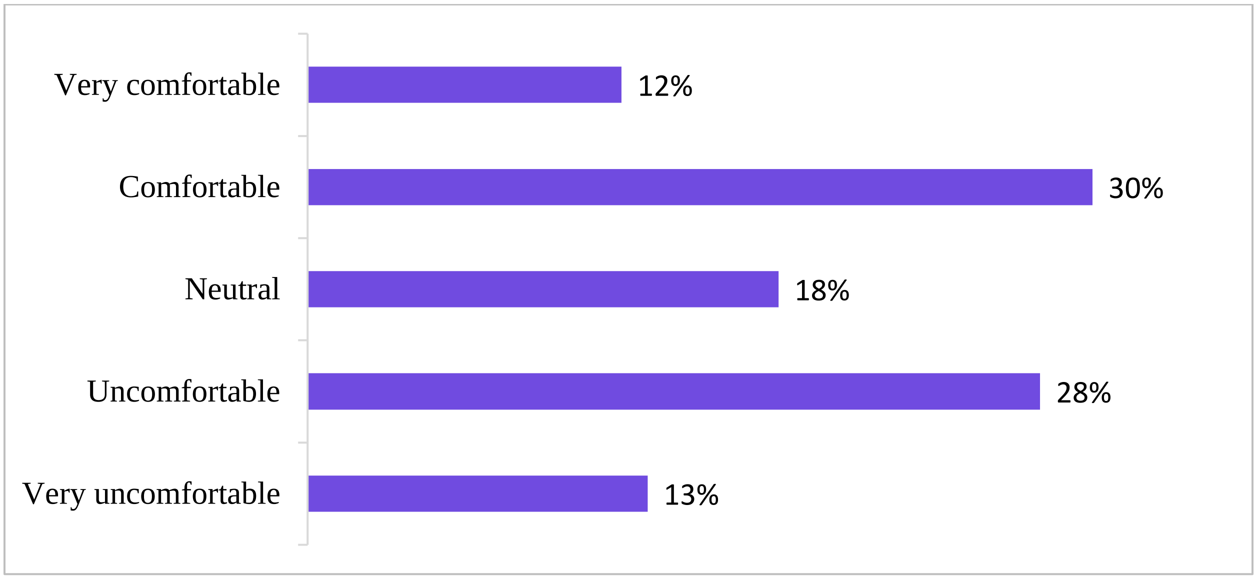

Figure 3.3 Drivers' comfortability in overtaking on a 2-way 2-lane road in the presence of CAVs

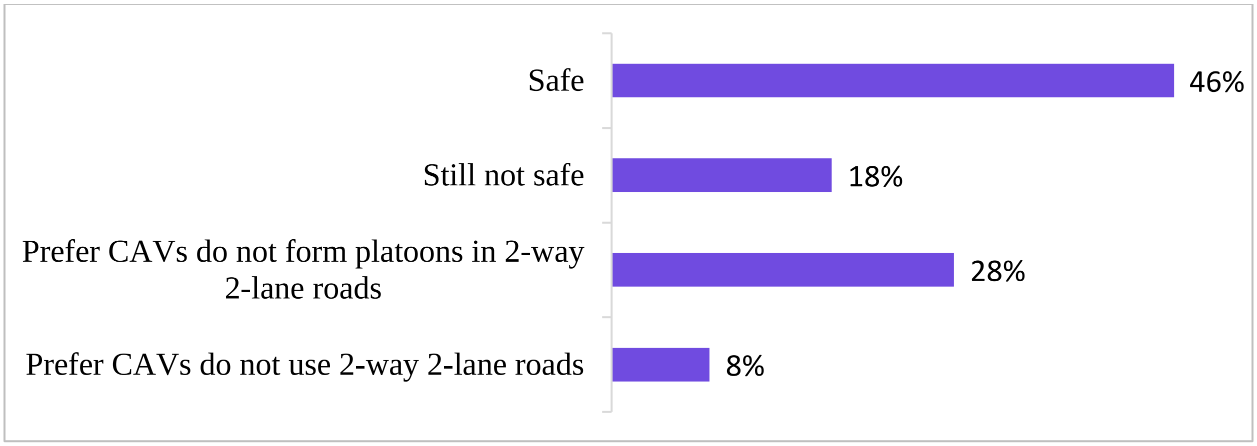

Figure 3.4 Drivers' feeling of safety with a platoon of CAVs as the lead vehicles that are able to detect the overtaking cars and increase the gap within the platoon for easier passing

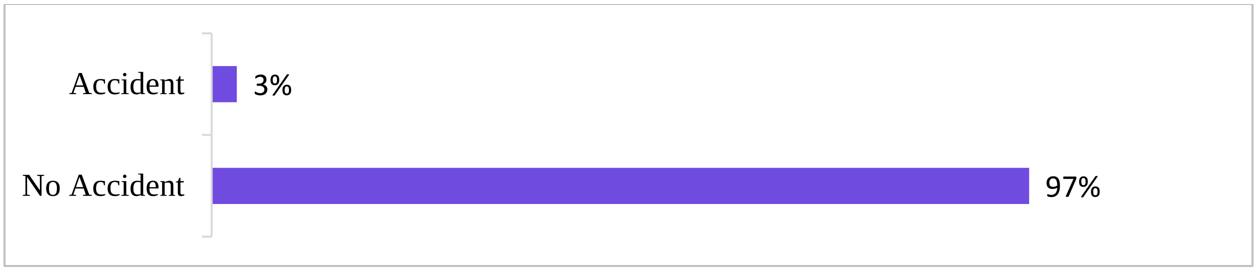

Figure 3.5 Drivers' involvement in an accident due to overtaking maneuvers on 2-way 2-lane roads in the last 3 years

5.1.4 Scenario 4: Drivers' reactions and preferences towards CAVs on Multi-Lane Highways

In scenario 4, drivers were asked about overtaking and passing maneuvers on multi-lane highways in the presence of CAVs platoon consisting of passenger cars and trucks as described in Figure 8 and Figure 9 in *Section 3.1 Survey Content.* For the first question in Figure 4.1 on driving behavior, respondents were asked about their decision on whether they would not overtake the platoon of CAVs they are currently following or switch lanes just to avoid driving behind the platoon of CAVs. The majority of participants (86%) claimed that they would switch lanes just to avoid driving behind the platoon of CAVs while the rest (about 14%) stated that they would continue on the same lane following the platoon of CAVs. When questioned about preference on CAVs speed for drivers to continue driving behind the platoon, a 5-10 mph over speed is preferred (43%) with 10-15 mph overspeed and at speed limit receiving similar frequencies of 27% and 26%, and the last few percentages (5%) following if the CAVs overspeed above 15 mph showcased in Figure 4.2. For driving comfortability, almost three quarters of participants (74%) reported that they would feel comfortable or very comfortable. On the other hand, only 9% stated that they would feel uncomfortable or very uncomfortable as shown in Figure 4.3.

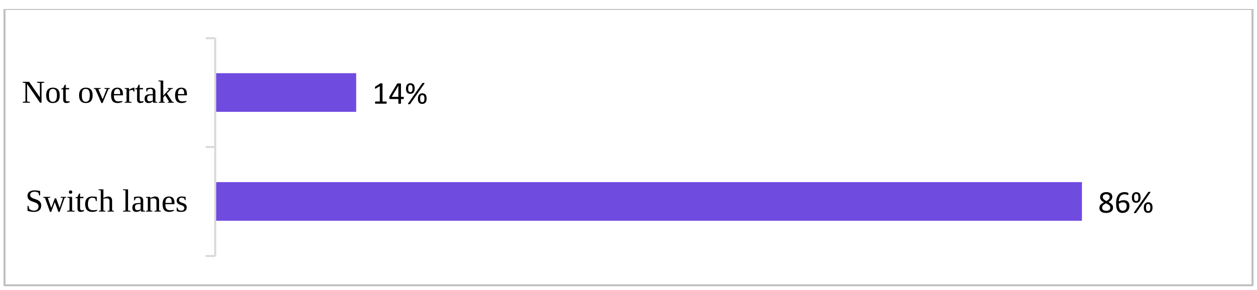

Figure 4.1 Drivers' behavior following behind a platoon of CAVs on a 3-lane highway

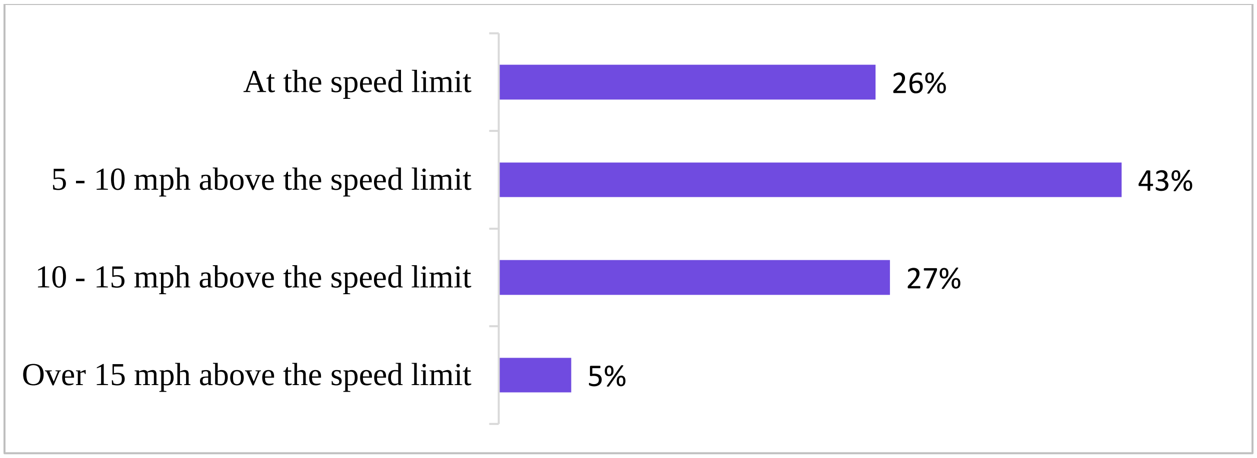

Figure 4.2 Drivers' preferred speed of the CAVs to continue driving behind the platoon on a 3-lane highway

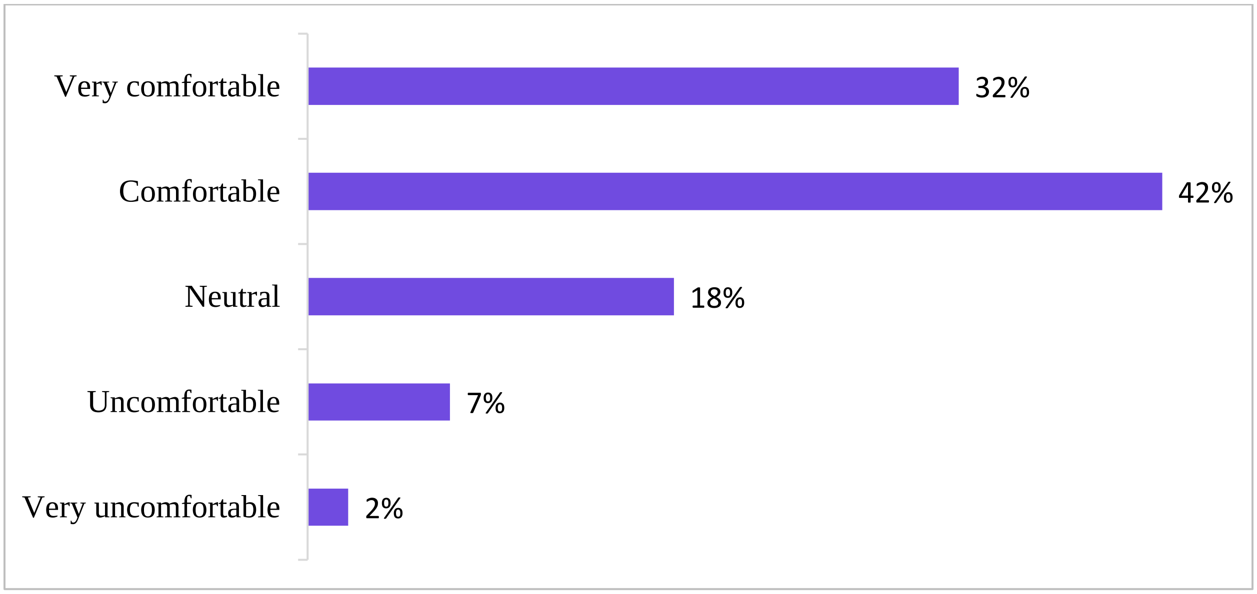

Figure 4.3 Drivers' comfortability in overtaking on a multi-lane highway in the presence of CAVs

Participants were asked the same questions in Scenario 4 while following a platoon of CAVs on multilane highway that is consisting of truck. The findings revealed that the majority of respondents (83%) prefer to switch lanes to avoid driving behind the platoon and 17% opted to not overtake and stay behind the platoon of truck CAVs as shown in Figure 4.4. Drivers' preference of the speed of the truck CAVs to continue following behind the platoon gravitated towards overspeed of 5-10 mph over the speed limit (47%), following at the speed limit (27%), 10-15 mph overspeed garnering 21%, and the rest (6%) following if the CAVs were to drive 15 mph above the speed limit seen in Figure 4.5. The last question regarded involvement in accidents due to overtaking maneuvers on multi-lane highways from which most (96%) indicated no prior accidents in the last 3 years with only 4% replying 'yes' to an accident.

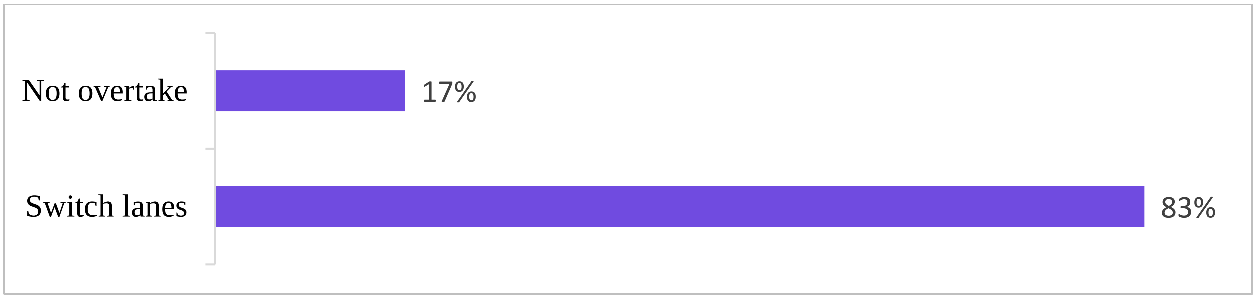

Figure 4.4 Drivers' behavior following behind a platoon of truck CAVs on a 3-lane highway

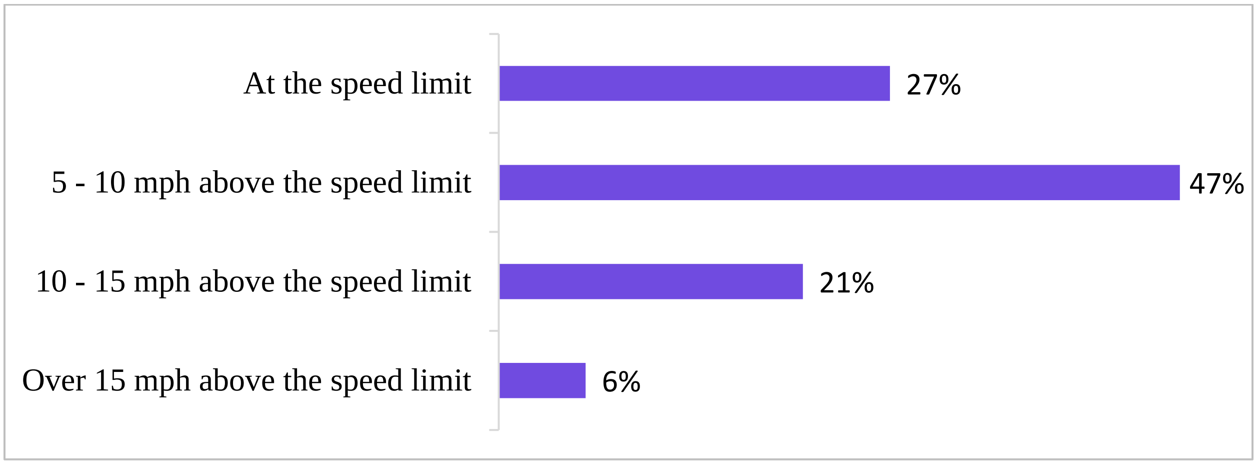

Figure 4.5 Drivers' preferred speed of the truck CAVs to continue driving behind the platoon on a 3-lane highway

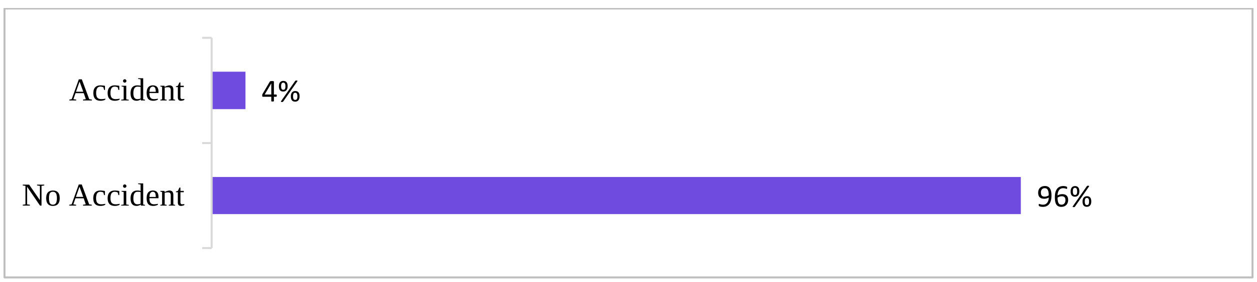

Figure 4.6 Drivers' involvement in an accident due to overtaking maneuvers on multi-lane highways in the last 3 years

5.1.5 Scenario 5: Drivers' reactions and preferences towards CAVs on Multi-Lane Highways During Critical Weather Conditions

The last investigated scenario dealt with drivers' interactions with CAVs on multi-lane highways during critical weather conditions as outlined in Figure 10 and 11 of *Section 3.1 Survey Content*. The findings revealed that over half of the drivers (58%) would ignore the platoon and continue on the same lane if they are travelling in critical weather conditions after having noticed the platoon of CAVs on the adjacent lane. Less than a third (26%) indicated that they would change lane to follow behind the platoon and 16% would follow the speed of the CAVs but continue on their respective lane as illustrated in Figure 5.1. If the drivers were to receive an alert suggesting following the platoon of CAVs because of a hazardous situation on the road ahead as a result of the critical weather conditions, more than two thirds of participants in this study (68%) reported that they would choose to follow behind the platoon while the rest (32%) stated that they would not follow behind the CAVs platoon as shown in Figure 5.2. In terms of driving comfortability, as seen in Figure 5.3, during critical weather conditions in the presence of CAVs, the most chosen is comfortable at 42%, neutral at 28%, very comfortable at 14%, uncomfortable at 13%, and very uncomfortable at about 3% of the remainder drivers.

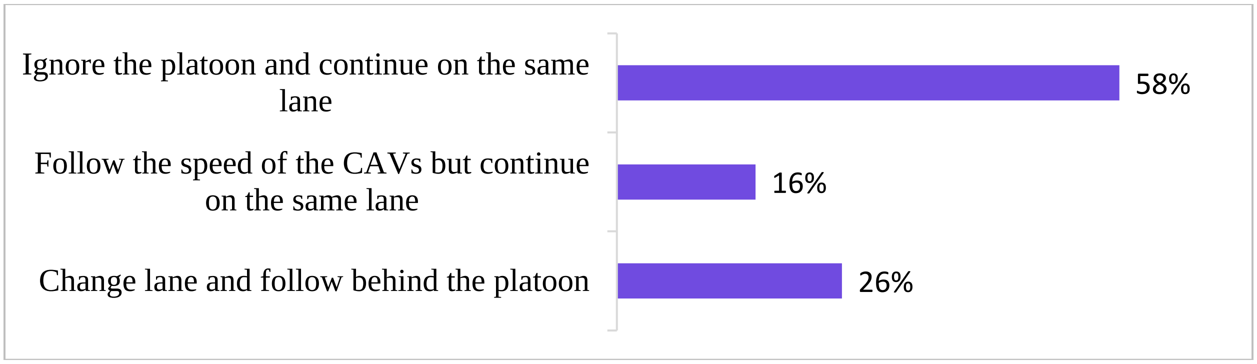

Figure 5.1 Drivers’ behavior when travelling in critical weather conditions after noticing a platoon of CAVs on the adjacent lane

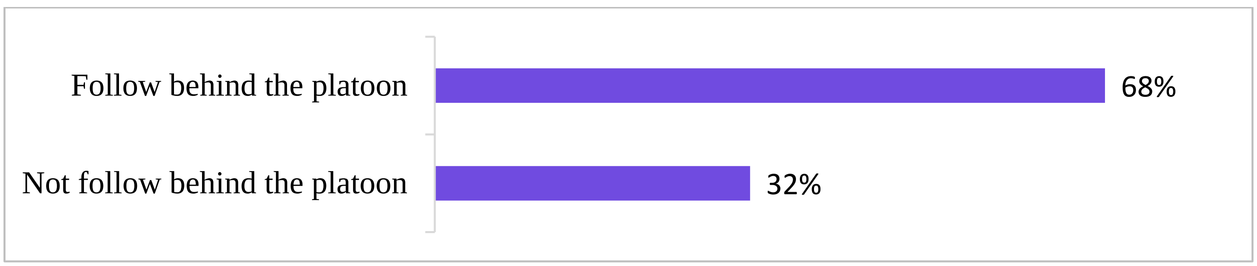

Figure 5.2 Drivers’ behavior after receiving an alert suggesting following the platoon of CAVs because of a hazardous situation on the road ahead as a result of the critical weather conditions

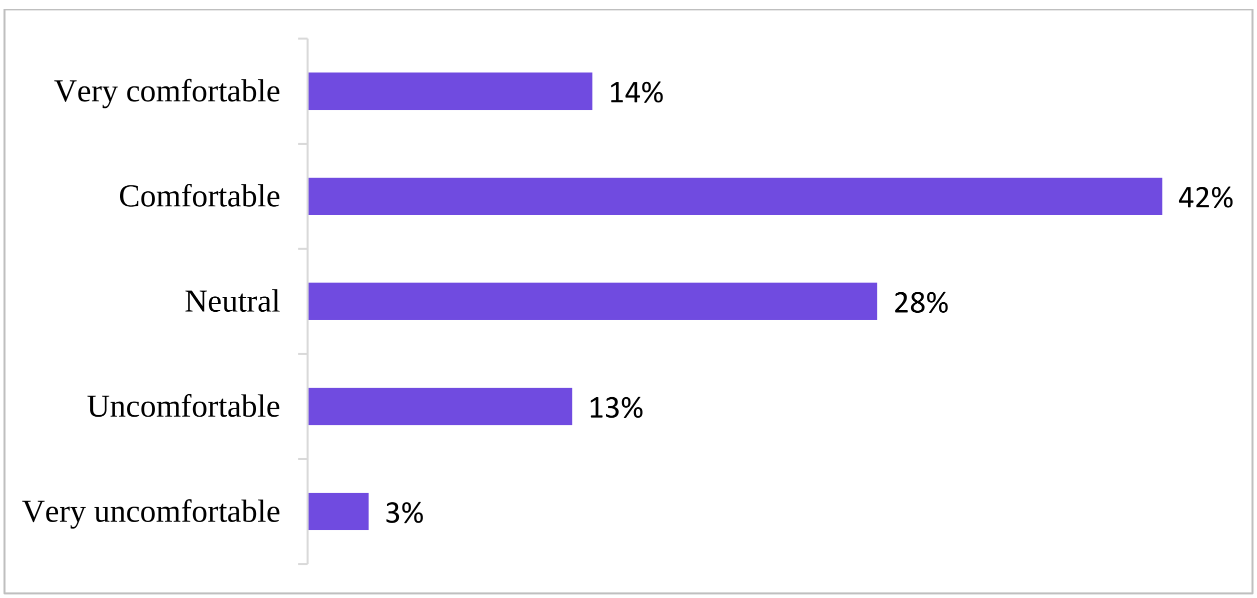

Figure 5.3 Drivers’ comfortability during critical weather conditions in the presence of CAVs

In Figure 5.4, if it were a platoon of CAVs consisting of trucks rather than a platoon consisting of passenger cars, drivers were still likely to ignore the platoon and continue on their respective lane (60%). About 21% and 19% are reserved for following the speed of the platoon but staying on their lane and the latter for changing lane and following behind the platoon of truck CAVs. If given the same alert suggesting following the platoon of CAVs because of a hazardous situation on the road, more than half of survey's respondents (59%) claimed that they would take the advice of the alert and follow behind the platoon but the rest (41% of the respondents) reported that they would not comply to the given alert (as shown in Figure 5.5). The final question for this scenario revealed similar findings of most drivers not having had an accident due to critical weather conditions while driving (96%) but with a few (4%) having had experienced an accident in the last three years (as shown in Figure 5.6).

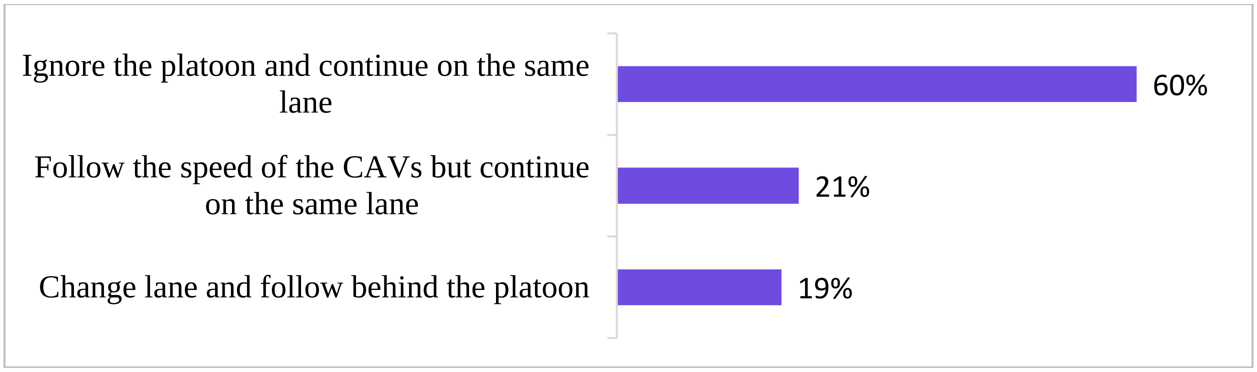

Figure 5.4 Drivers' behavior travelling in critical weather conditions noticing a platoon of truck CAVs on the adjacent lane

Figure 5.5 Drivers' behavior after receiving an alert suggesting following the platoon of truck CAVs because of a hazardous situation on the road ahead as a result of the critical weather conditions

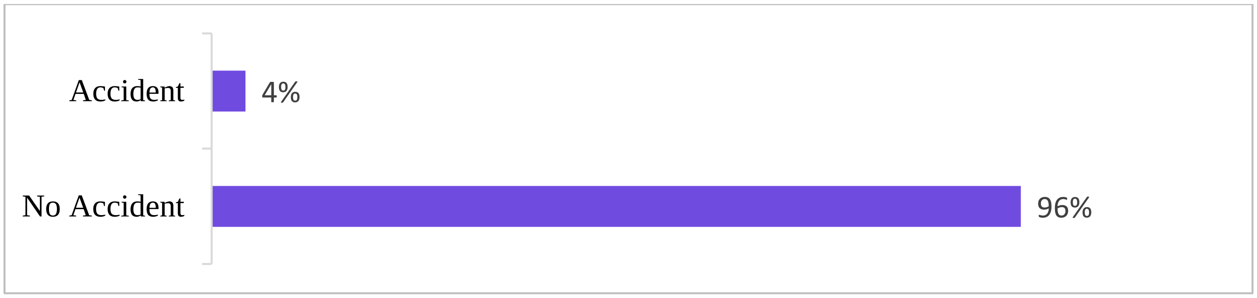

Figure 5.6 Drivers' involvement in an accident due to the critical weather conditions on multi-lane highways in the last 3 years

5.1.6 Section 6: Drivers' Preference and Willingness towards CAVs

Besides the five abovementioned scenarios, four questions were asked about the participants' preferences and wiliness to imitating the CAVs' driving behavior as well as their intentions in purchasing a vehicle with CAV capabilities. It begins with Figure 6.1 where drivers were asked if they would follow the speed of a nearby platoon of CAVs if they did not know the speed limit of their current travelling road. Less than half (43%) indicated that the presence of CAVs would have no influence on their speed as they would determine their vehicle's speed based on their own judgement. However, one third of respondents (33%) expressed that they would follow the speed of the platoon while the rest (24%) would follow the speed of other surrounding human-driven vehicles instead. When investigating whether a driver would imitate the tight headways of the CAVs on the adjacent lane (as shown in Figure 6.2), most of participants (74%) indicated that they would not follow the same headway space with only 26% revealing that they would imitate the CAV's headways. If instead, the drivers were following behind the CAVs rather than having the platoon be on the adjacent lane, drivers were asked the same question seen in Figure 6.3, however, a greater percentage of 81% expressed that they would not imitate the headway with only 19% selecting that they would follow the same vehicle gap. The final question asked in this section (Figure 6.4) was about the drivers' willingness to purchase a vehicle with CAV capabilities from which about half (48%) declaring that they had no intention to buy one. However, about one third (32%) indicated that they would buy only if the price is similar to that of a traditional vehicle, and 15 % would buy when at least 50% of the roadway vehicles are CAVs, and only 5% opting to buy one as soon as the vehicles are commercially available.

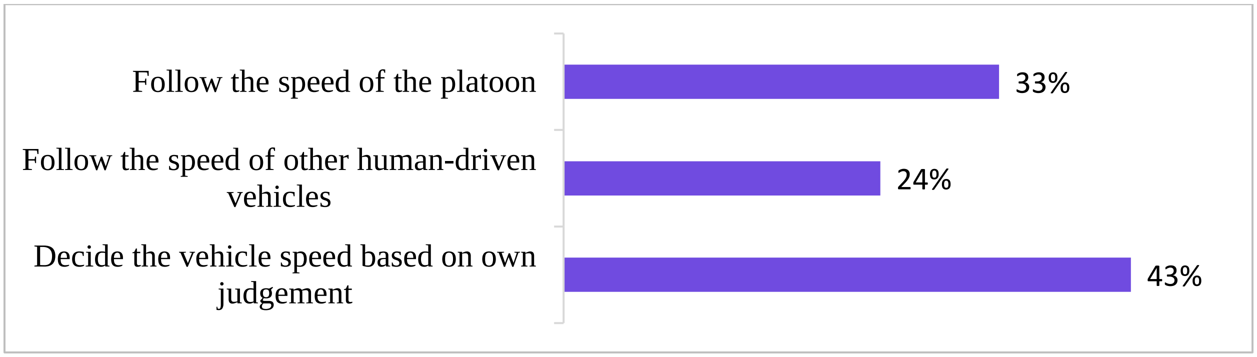

Figure 6.1 Drivers' behavior driving in a roadway without knowing the speed limit with a platoon of CAVs on the adjacent lane

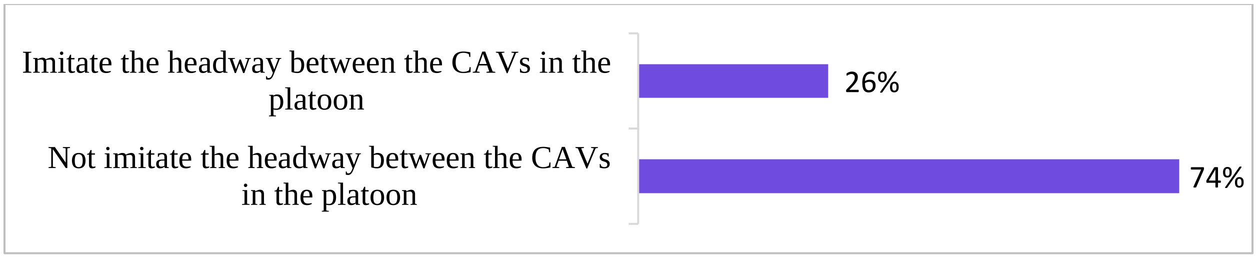

Figure 6.2 Drivers' behavior following behind a human-driven vehicle with a platoon of CAVs with small headways on an adjacent lane

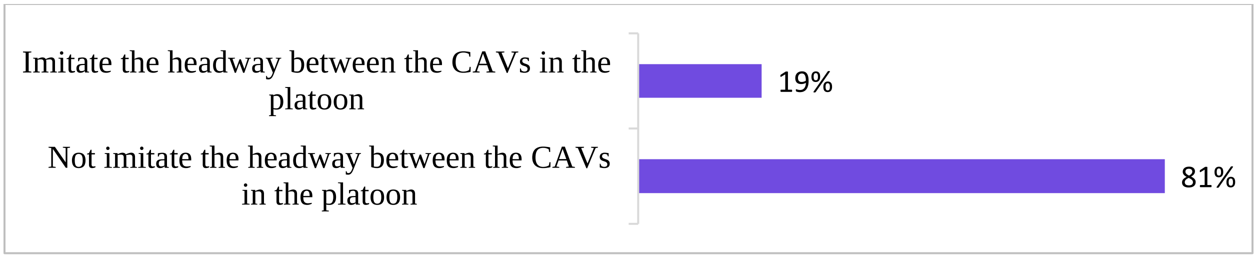

Figure 6.3 Drivers' behavior following behind a platoon of CAVs with small headways

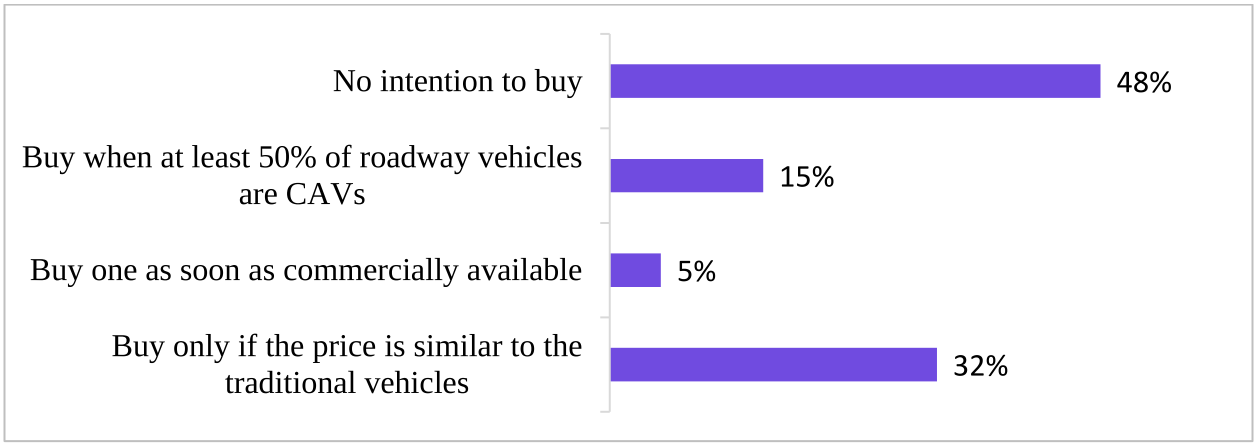

Figure 6.4 Drivers' willingness to buy a vehicle with CAV technology in the near future

5.2 Multivariate Analysis

To assess the survey data through multivariate analysis, two-way association test was first implemented to identify significant associations between the dependent variable and its corresponding independent variables. The frequency tables in *Section 5.1 Descriptive Analysis* serve as the founding basis from which the SAS program decoded to give the following results. After identification of which independent variables affect a specific behavior or drivers' willingness, logistic regression models were created for each appropriate equation or relationship. In these cases, the dependent variables or questioned analyzed were Scenario 1 – Figure 1.1 (Drivers' behavior when merging onto the highway with a platoon of CAVs on the adjacent lane blocking immediate change in lane), Scenario 3 – Figure 3.1 (Drivers' behavior when overtaking and passing a platoon of CAVs on a 2-way 2-lane road), Scenario 5 – Figure 5.5 (Drivers' behavior after receiving an alert suggesting following the platoon of truck CAVs because of a hazardous situation on the road ahead as a result of the critical weather conditions), and Section 6 – Figure 6.4 (Drivers' willingness to buy a vehicle with CAV technology in the near future). The corresponding independent questions are outlined in the following labeled "Variable" that are significant with 90% confidence associated with the P values under the "Pr> |t|" column under the Parameter Estimates tables. It is noted that all of the outlined models have a goodness of fit value (R-Square) that are less than 0.5 indicating that less than half of the variance in the outcome are explained by the model as seen in Figure 12.

Question 1.1

Root MSE	0.42843	**R-Square**	0.2483
Dependent Mean	0.35833	**Adj R-Sq**	0.2084
Coeff Var	119.56150		

Question 3.1

Root MSE	0.43356	**R-Square**	0.2247
Dependent Mean	0.37500	**Adj R-Sq**	0.2046
Coeff Var	115.61724		

Question 5.5

Root MSE	0.46214	**R-Square**	0.1528
Dependent Mean	0.59167	**Adj R-Sq**	0.1234
Coeff Var	78.10763		

Question 6.4

Root MSE	0.45182	**R-Square**	0.2166
Dependent Mean	0.51667	**Adj R-Sq**	0.1894
Coeff Var	87.44836		

Figure 12: Goodness of Fit Values for the Dependent Variables Q1.1 (Scenario 1 – Figure 1.1), Q3.1 (Scenario 3 – Figure 3.1), Q5.5 (Scenario 5 – Figure 5.5), Q6.4 (Section 6 – Figure 6.4)

5.2.1 Factors Affecting (Q1.1) Drivers' Behavior when Merging onto the Highway with a Platoon of CAVs on the Adjacent Lane Blocking Immediate Change in Lane

Table 2 shows the results of the logistic regression model that was developed to identify the factors affecting drivers' behavior when merging onto the highway with a platoon of CAVs on the adjacent lane blocking immediate lane change. The positive correlation under the "Parameter Estimate" on Table 2 for the independent variable Q1.2 shows that the drivers who prefer shorter vehicle gap between the CAVs to break the platoon to enter the main highway, are also the ones more willing to go faster and overtake or immediately break the platoon. From the negative relationship of Q1.3 to the dependent question, drivers that are more uncomfortable with leaving the on-ramp lane to merge with the highway in the presence of CAVs on the adjacent lane are also the ones that are more likely to break the platoon or over speed past the CAVs. Contrarily, a driver who does not know the speed limit of a roadway and chooses to follow the speed of other human-driven vehicles or use their own judgement to decide their own speed are also the ones who would change lanes by breaking or overtaking the platoon. From this negative association between Q6.1 and Q1.1 as aforementioned, it can also be said that those who do not know the speed limit but would follow the speed of the CAVs are the drivers who would continue moving on the same on-ramp lane until CAVs clear the adjacent lane even if the driver stops the vehicle completely at the end of the lane. When testing the demographics of the participants from the independent variable Q7.2, it was found that younger drivers at a range of 16 to 24 years of age are the ones that would choose to break the platoon or overtake it to merge with the highway. On the other hand, those that have a level of education of a bachelor's degree or higher are the drivers that would drive faster past the CAVs or immediately break the platoon to enter the main highway according to the negative association between Q7.3 and Q1.1. Likewise, for those that are considered employed are the drivers that prefer to break the platoon or overtake it rather than wait at the end of the ending on-ramp lane as seen once again by the negative correlation between Q7.4 and Q1.1. The recipients who indicated that they are either unemployed or retired or other, are the ones discovered to be more inclined to continue on the same travel lane until the platoon of CAVs on the adjacent lane are cleared.

Table 2: Parameter Estimates for the Dependent Variable Q1.1 and Independent Variables Q1.2, Q1.3, Q6.1, Q7.2, Q7.3, Q7.4

Parameter Estimates						
Variable	**Label**	**Label Coding**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Q1.2	Drivers' preferred vehicle gap between the CAVs if they must break the platoon to enter the main highway	0 - At least 3+ vehicle-length away 1 - At least 2 vehicle-length away 2 - At least 1 vehicle-length away 3 - No preference	0.127	0.046	2.75	0.007
Q1.3	Drivers' comfortability in using the on-ramp lane in the presence of CAVs	0 - Very uncomfortable 1 - Uncomfortable 2 - Neutral 3 - Comfortable 4 - Very comfortable	-0.074	0.040	-1.9	0.065
Q6.1	Drivers' behavior driving in a roadway without knowing the speed limit with a platoon of CAVs on the adjacent lane	0 - Use their own judgement to decide the speed 0 - Follow the speed of other surrounding human-driven vehicles 1 - Follow the speed of the nearby CAVs platoon	-0.200	0.084	-2.4	0.019
Q7.2	Age	0 - 66+ 0 - 56-65 0 - 41-55 0 - 25-40 1 - 16-24	0.197	0.084	2.34	0.021
Q7.3	Level of Education	0 - Bachelor's degree 0 - Master's degree 0 - Doctorate degree 0 - Other 1 - No certification 1 - High school diploma 1 - College diploma 1 - Associate degree	-0.276	0.083	-3.3	0.001
Q7.4	Employment Status	0 - Employed 1 - Unemployed 1 - Retired 1 - Other	-0.238	0.108	-2.2	0.029
Q1.1	Drivers' behavior when merging onto the highway with a platoon of CAVs on the adjacent lane blocking immediate change in lane	0 - Continue moving in the same lane until the platoon are cleared from the adjacent lane, even if they will stop their vehicle completely before changing lanes 1 - Change lane by breaking the platoon of CAVs 1 - Go faster and overtake the platoon even if they will be going above the speed limit				

5.2.2 Factors Affecting (Q3.1) Drivers' Behavior when Overtaking and Passing a Platoon of CAVs on a 2-Way 2-Lane Road

Table 3 shows the results of the logistic regression model that was developed to identify the factors affecting drivers' behavior when overtaking a platoon of CAVs on a 2-Way 2-lane road. Under the "Parameter Estimate" of Table 3 below, it can be seen that all of the independent variable questions have positive relationships with the dependent variable Q3.1 described as the drivers' behaviors when overtaking and passing a platoon of CAVs on a 2-way 2-lane road. The connection reveals that those who favor over speeding are the drivers that would attempt to overtake each CAVs or the entire platoon on this roadway scenario. On the other hand, according to the relationship between Q3.4 those who feel safe with the CAVs' detection of the merging car for easier overtaking and passing are the drivers who would attempt to overtake and pass the platoon of CAVs in one attempt or one at a time. Lastly still, those who have had accidents due to overtaking maneuvers on 2-way 2-lane roads are more prone to overtake and pass the CAVs corresponding to the outlined positive correlation between Q3.5 and the dependent variable in question.

Table 3: Parameter Estimates for the Dependent Variable Q3.1 and Independent Variables Q3.2, Q3.4, Q3.5

Parameter Estimates						
Variable	**Label**	**Label Coding**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Q3.2	Drivers' preferred speed of the CAVs to continue driving behind the platoon on a 2-way 2-lane road	0 - At the speed limit of the road 1 - 5-10 mph above the speed limit of the road 2 - 10-15 mph above the speed limit of the road 3 - Over 15 mph above the speed limit of the road	0.217	0.051	4.29	<.0001
Q3.4	Drivers' feeling of safety with a platoon of CAVs as the lead vehicles that are able to detect the overtaking cars and increase the gap within the platoon for easier passing	0 - Do not feel safe 0 - Prefer that CAVs do not form platoons in 2-way 2-lane roads 0 - Prefer that CAVs do not use 2-way 2-lane roads 1 - Feel safe	0.198	0.081	2.44	0.016
Q3.5	Drivers' involvement in an accident due to overtaking maneuvers on 2-way 2-lane roads in the last 3 years	0 - No accident 1 - Accident	0.595	0.226	2.64	0.010
Q3.1	Drivers' behavior when overtaking and passing a platoon of CAVs on a 2-way 2-lane road	0 - Do not overtake and pass the platoon as it is risky to overtake multiple vehicles on a 2-way 2-lane road 1 - Overtake and pass each CAVs in the platoon one at a time 1 - Overtake and pass the entire platoon of CAVs in one attempt				

5.2.3 Factors Affecting (Q5.5) Drivers' Behavior After Receiving an Alert Suggesting Following the Platoon of Truck CAVs Because of a Hazardous Situation on the Road Ahead as a Result of the Critical Weather

From the logistic regression model between the dependent variable question Q5.5 for drivers' behavior after receiving an alert suggesting following a platoon of CAV due to a hazardous situation on the road ahead because of the critical weather roadway condition and its independents. The first connection begins with Q5.3 with a positive parameter estimate indicating that drivers who felt more comfortable with the presence of CAVs during critical weather conditions are the ones more obliged to follow behind the platoon of truck CAVs as advised by the alert suggestion. On the topic of a drivers' willingness to buy a vehicle with CAV technology in the near future from Q6.4, it is discovered that those who do have an intention to purchase either as soon as they are commercially available, or when at least 50% of the roadway vehicles are already CAVs or if the purchasing price is similar to that of a traditional vehicle, are the same drivers who would abide by the alert suggestion. From Q7.7 regarding total household income, it was found that as the income decreases from above $90,00 to less than $20,000, a drivers' compliance to the alert suggestion following the platoon of trucks will increase. In other words, those with lower income will more likely listen to the suggestion than those with higher incomes who would not follow behind the platoon. On the other hand, participants with more driving experience are the drivers who would follow behind the platoon of truck CAVs when advised to do so because of a hazardous situation on the road ahead because of the critical weather condition.

Table 4: Parameter Estimates for the Dependent Variable Q5.5 and Independent Variables Q5.3, Q6.4, Q7.7, Q7.8

Parameter Estimates						
Variable	**Label**	**Label Coding**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Q5.3	Drivers' comfortability during critical weather conditions in the presence of CAVs	0 - Very uncomfortable 1 - Uncomfortable 2 - Neutral 3 - Comfortable 4 - Very comfortable	0.087	0.043	2.05	0.043
Q6.4	Drivers' willingness to buy a vehicle with CAV technology in the near future	0 - No intention to buy 1 - Buy when at least 50% of vehicles on the roadway are CAVs 1 - Buy as soon as commercially available 1 - Buy if the price is similar to human-driven vehicles	0.222	0.087	2.56	0.012
Q7.7	Total Household Income	0 - Less than $20,000 1 - $20,000 to $49,999 2 - $50,000 to $89,999 3 - Above $90,000	-0.077	0.042	1.84	0.069
Q7.8	Driving Experience	0 - More than 5 years 1 - 2 – 5 years 2 - Less than 2 years	-0.198	0.064	-3.1	0.002
Q5.5	Drivers' behavior after receiving an alert suggesting following the platoon of truck CAVs because of a hazardous situation on the road ahead as a result of the critical weather conditions	0 - Do not follow behind the platoon of truck CAVs 1 - Follow behind the platoon of truck CAVs				

5.2.4 Factors Affecting (Q6.4) Drivers' Willingness to Buy a Vehicle with CAV Technology in the Near Future

Investigation in respect to drivers' willingness to buy a vehicle with a CAV technology in the near future unveiled that the independent variables Q4.3, Q5.5, Q7.5, and Q7.8 are the factors found under Table 5 that affect intentions of purchasing. To begin, a driver's comfortability (Q4.3) in overtaking on a multi-lane highway in the presence of CAVs as described in Scenario 4 is positively associated with willingness to purchase. It is determined that drivers that are more comfortable with overtaking CAVs on multi-lane highways are also the ones more inclined to purchase CAV technology vehicles as soon as they are commercially available, or if the price is similar to that of a traditional vehicle or when at least 50% of vehicles on the roadway are CAVs. As seen in *Section 5.2.3*, the positive correlation between Q5.5 and Q6.4 shows that drivers who would comply with the alert suggestion to follow a platoon of truck CAVs during critical weather conditions are more likely to purchase a vehicle with CAV capabilities. From the negative association of variable Q7.5 with the dependent Q6.4, it is regarded that those who reside in urban or suburban areas are the drivers that would be more inclined to purchase such vehicle. Lastly, from the positive parameter estimate findings of Q7.8 in Table 5, it can be concluded that those with less driving experience are the ones who are more willing to have a vehicle with CAV technology in the near future.

Table 5: Parameter Estimates for the Dependent Variable Q6.4 and Independent Variables Q4.3, Q5.5, Q7.5, Q7.8

Parameter Estimates						
Variable	**Label**	**Label Coding**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Q4.3	Drivers' comfortability in overtaking on a multi-lane highway in the presence of CAVs	0 - Very uncomfortable 1 - Uncomfortable 2 - Neutral 3 - Comfortable 4 - Very comfortable	0.125	0.044	-2.8	0.006
Q5.5	Drivers' behavior after receiving an alert suggesting following the platoon of truck CAVs because of a hazardous situation on the road ahead as a result of the critical weather conditions	0 - Not follow behind the platoon of truck CAVs 1 - Follow behind the platoon of truck CAVs	0.253	0.086	2.94	0.004
Q7.5	Residential Area	0 - Urban area 0 - Suburban area 1 - Rural area	-0.249	0.100	-2.5	0.014
Q7.8	Driving Experience	0 - More than 5 years 1 - 2 – 5 years 2 - Less than 2 years	0.144	0.061	2.35	0.021
Q6.4	Drivers' willingness to buy a vehicle with CAV technology in the near future	0 - No intention to buy 1 - Buy when at least 50% of vehicles on the roadway are CAVs 1 - Buy as soon as commercially available 1 - Buy if the price is similar to human-driven vehicles				

6. Discussion

From the logistic model discussed in *Section 5.2 Multivariate Analysis*, the following findings are derived according to the analyzed relationship between the dependent and independent variables. With the influence of CAVs on driver's decision on various roadway scenarios, there can be two outlooks in the vehicles impact. It could consequently encourage aggressive behavior because of desires to not be in the presence of CAVs or it could possibly assist drivers in stressful roadway scenarios. The following four model discussion will reveal two supports for each consequence derived from the findings found in the abovementioned section.

Firstly, in Scenario 1 involving a platoon of CAVs in the adjacent lane to an on-ramp lane, it can be said that drivers that are younger, more educated, and employed are the ones that are more willing to change lane immediately to merge with the highway by breaking the platoon of CAV or increasing their speed to overtake the platoon of CAVs even if they will be going above the speed limit. It can be speculated that these demographic characteristics are the ones that have had prior knowledge about CAVs before the survey was conducted from which they were more informed in the capabilities of the vehicles making them confident to break the platoon or overtake the CAVs . It is also revealed that those that are more uncomfortable with having CAVs on the adjacent lanes of on-ramp areas are the ones that would break or overtake the platoon. It can be speculated that because drivers prefer to not be next to CAVs, they would resort to more aggressive behavior of going faster to overtake or break the platoon of CAVs for immediate enter unto the highway even if the CAVs within the platoon have shorter headways. This aggressive inclination can also be seen from the finding that those that chose to not wait for the CAVs to clear the adjacent lane are the ones that have no preferences in vehicle gap length within the platoon or are more tolerate of shorter headways as they will either speed past the CAVs or cut in between the platoon regardless of the distance between the vehicles. Drivers that are skeptical of CAVs and would instead use their own judgement in determining their speed if the speed limit is unknown or follow the speed of other drivers rather than the CAVs on their adjacent lane are also the participants who would behave more aggressively in this scenario by breaking the platoon or overtaking the CAVs for immediate change in lane. This choice could be because of the drivers' distrust on the CAVs in wanting to minimize further interaction with the platoon by overtaking or breaking the platoon for immediate entering unto the highway. The results of this study imply that having CAVs in the most-right lane of the highway at on-ramp regions may make drivers more aggressive while merging with the highway.

Another aggressive driving behavior can also be seen in Scenario 3 regarding the choice to overtake and pass a lead platoon of CAV on a 2-way 2-lane road. The findings reveal that drivers that would attempt to overtake the entire platoon or every vehicle of a platoon at a time are affected by three variables. Those that already tend to overspeed and would only follow behind CAVs if the platoon was speeding over the speed limit are the ones that chose to behave aggressively and overtake as they would rather have the freedom to speed faster than that which is recommended. Drivers that have had prior accidents due to the same maneuvers of overtaking and passing on 2-way 2-lane roads are still the ones that would risk overtaking an entire platoon of vehicles or one vehicle at a time just to drive at a much faster speed. This indicates that rather than being more cautious of overtaking in 2-way 2-lane roads due to prior accidents, drivers would be more likely to continue in this aggressive behavior. Likewise, if it was suggested that the CAVs would aid in overtaking through detection and increase in headways, drivers that would feel safe because of this

CAV technology are the ones more willing to aggressively overtake rather than follow behind the platoon because they feel that they are accommodated in this more dangerous driving behavior. This finding for this dependent variable reveals that aggressive behavior could be heightened and supported if CAVs were to travel on 2-way 2-lane roads.

Contrarily to the aggressive driving decisions mentioned above, it was found that in Scenario 5 with a platoon of truck CAVs, drivers would comply more often to an alert suggesting following the truck CAVs because of a hazardous situation on the road ahead as a result of critical weather conditions. This compliant behavior towards the driving suggestion is affected by the drivers' feeling of comfortability with the presence of CAVs in the roadway during critical weather condition. This can indicate that the drivers who find it comfortable to drive with platoon of truck CAVs in this roadway scenario are more trusting of the vehicle's capabilities and abide by the suggestion. The trust and comfort on the CAVs are also joined by driving experience and total household income to influence a drivers' decision in this roadway scenario. It is revealed also that those that have longer driving experience and have lower income but are more likely to purchase vehicles with CAV technology in the near future are also the ones that would be more willing to obey the alert suggestion. Drivers with longer driving experience could have understood that a hazardous situation on the road ahead could cause delay in travel or more danger and would follow behind the CAVs for cautionary reasons. Those with lower income can be associated with drivers with older vehicles that may not be equipped to handle a hazardous roadway situation and would be more willing to get help and guidance from surrounding vehicles which in this case is the platoon of truck CAVs. Similarly, those that are wanting to purchase vehicles with CAV technology are the ones that would be already accepting of the alert suggestion as it is an advancement that the smart technology is capable of doing through V2V and V2I communication.

The last dependent variable investigated was willingness to purchase a vehicle with CAV technology either as soon as they are commercially available or when their prices are similar to that of a traditional vehicle or when at least 50% of the vehicles on the roadways are CAVs. The findings suggested that those that have less driving experience and reside in urban/suburban areas would be keener to purchasing a vehicle with CAV technology. A plausible reason for drivers with less driving experience wanting to purchase the smart vehicles are that they require more assistance to drive safely and when confronted by a stressful roadway situation. The explanation behind the urban/suburban affecting factor would be that drivers that drive in busier roadways are more acceptable to purchasing vehicles that will help in their driving experience and safety. It is found surprisingly that two scenarios have affected a drivers' willingness to purchase CAV technology. The first that of Scenario 4 described specifically regarding driving comfortability in overtaking on a multi-lane highway in the presence of CAVs. The findings revealed that those that are generally more comfortable with this driving behavior are more likely to purchase the CAV. This can be potentially because as drivers grow to see more CAVs on multi-lane highways and are more comfortably and easily overtake platoon of CAVs, they would be more exposed to the CAV technology and therefore cause them to consider purchasing a vehicle with CAV technology. For drivers in Scenario 5 that comply with the alert suggestion of following behind the platoon of truck CAVs, there is a found connection for them to more likely purchase the technologically advanced vehicles. A possible reasoning would be that as drivers begin to abide by the V2V technology or even V2I technology alerts and suggestions, there is more willingness to purchase a vehicle with the abovementioned abilities.

7. Conclusion

To further understand the influence of CAVs on the transportation system in mixed traffic network, this study investigated a driver's behavior, expectations and preferences when drivers are situated in various roadway scenarios involving a platoon of CAVs consisting of passenger cars or trucks. The findings have revealed that because of the platoon's tight headway, aggressive behavior could be observed from other human driven vehicles (from those that have generally driven less defensively). Drivers who found it uncomfortable leaving an on-ramp lane to merge with the highway in the presence of CAVs are those who would break the platoon regardless of the headway length or over speeding to overtake the entire platoon to immediately enter the main highway. Those drivers are descried to be well educated (e.g., having bachelor's degree or higher), younger, and employed that resort to more aggressive driving behavior to not prolong their interaction with CAVs. Overtaking and passing a platoon of CAVs was also a preferred choice for drivers that are following behind CAVs in 2-way 2-lane roads who have had prior involvement in an accident due to overtaking maneuvers on 2-way 2-lane roads.

In support of this aggressive tendency, these drivers also would only follow behind the CAVs on 2-way 2-lane roads if the platoon was travelling at a much faster speed than that of the speed limit. If the CAVs were to assist the drivers in overtaking the platoon through detection and increase the headway between its vehicles, the drivers felt it safe to have the CAVs as the lead vehicles. While this CAV defensive feature can help in mitigating the less cautious choices of drivers by compensating for the right of way infringement of the overtaking vehicle, the accommodate drivers could be more inclined to overtake each CAV one at a time or the entire platoon in one attempt.

On the contrary, the introduction of CAVs in the transportation system could yield benefits for drivers in need of help on the roadway. During critical weather conditions, drivers with more experience know to be more cautious of their surroundings and would be open to follow behind a platoon of truck CAVs if advised through an alert due to a hazardous situation on the road ahead. Likewise, drivers that generate lower household income would more than likely have vehicles without the appropriate capabilities of assisting them in harsh weather conditions and would be persuaded to follow the suggested alert of driving behind the CAVs. These drivers would be keener to purchasing a vehicle with CAV technology because they would find the stressful experience more comfortable as they did when in the presence of CAVs during critical weather condition. The availability and access to the CAVs was more desirable for drivers that reside in the busy urban/suburban areas and have less driving experience because of the extra assistance during demanding situations. Drivers willing to purchase these vehicles found it already comfortable overtaking CAVs in multilane highways in mixed traffic network with their traditional vehicles. The more comfortable drivers interact with CAVs, the more likely the public would be more prepared and wanting for the influence of CAVs.

From the findings of this study, transportation authorities and researchers are given the insight on the positive and negative consequences of CAVs. The potential shortcomings of the platoons due to aggressive drivers will require an effective countermeasure that does not only mitigate and compensate for this behavior but also encourage drivers to be more cautious and follow defensive driving maneuvers. Future policies and guidelines restricting certain driving behaviors in the presence of CAVs could be implemented to prevent reckless drivers to take advantage of the CAVs' defensive features. In the same manner, the advantages of the CAVs must be highlighted and stressed upon the public, especially for those that require further assistance during demanding and stressful roadway scenarios. The potential improvement in the safety and mobility of drivers because of the CAVs' presence in the roadway are of the many incentives from which the public can gain immediate benefit while in mixed traffic network. In balance, the potential influence of CAVs on a driver's experience and decisions can be circumstantial and is multifaceted with many contributing factors that require careful evaluation and extensive analysis.

Because of this, the study recognizes its shortcomings in gathering more survey data and its presentation of only four models highlighting the relationships between the studied variables that could affect a driver's decision under various roadway scenarios when in the presence of CAVs. It is recommended that a driving simulator experiment would be beneficial in recreating the described scenarios to further understand how affective the platoon of CAVs can be on drivers' willingness and behavior. In the same manner, a larger survey sample size could potentially strengthen the associations made in the models as well as possibly change the dynamics of the frequency to favor one choice behavior over the other thus consequently shifting the findings. It is also advised that future studies study other roadway scenarios involving CAVs and platoon of CAVs such as intersections, interaction with emergency vehicles or police cars, and CAV malfunction in addition to new independent variables that could influence the surrounding drivers in human-driven vehicles. The effect of V2V and V2I communication can also be further investigated regarding a recipient's response to alert and routing suggestions that can hinder a driver's original driving intention.

Acknowledgement

The financial support of the Transportation Consortium of South-Central States (Tran- SET) is greatly appreciated (Tran-SET Project No. 21ITSLSU16 and award No. AWD-003767).

I would like to first extend my utmost gratitude to my thesis advisor Dr. Hany Hassan for his support and patience throughout this research project. He has encouraged me to work in the best of my ability and has been a wonderful advisor in the past year.

I would also like to extend my gratitude to Taniya Sultana for working with me and providing invaluable insight and help in the development of the survey study. I hope for the best in her continuance of this study in pursuit of her academic excellence.

A sincere 'Thank You' to my thesis committee Dr. Bin Li of the Statistics department and Dr. Brian Wolshon of the Transportation department at LSU for participating in my defense and for providing insightful considerations to the study.

Lastly, I want to show my greatest appreciation for my family for their support and encouragement in my journey towards finishing my undergraduate honor's thesis. *Maraming Salamat po sa lahat na ginawa nyo para sa akin para matapos ko ang pag-aaral ko.*

Hallel u Ama Yahweh!

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