Measuring User Acceptance of and Willingness-to-Pay for CVI Technology

CVI UTC

CONNECTED VEHICLE/INFRASTRUCTURE UNIVERSITY TRANSPORTATION CENTER (CVI-UTC)

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Measuring User Acceptance of and Willingness-to-Pay for CVI Technology

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Consortium Members:
Virginia Tech Transportation Institute (VTTI),
University of Virginia (UVA) Center for Transportation Studies,
and Morgan State University (MSU)

Program Director:
Dr. Thomas Dingus
Program Director, Connected Vehicle/Infrastructure University Transportation Center
Director, Virginia Tech Transportation Institute
Professor, Department of Biomedical Engineering and Mechanics at Virginia Tech
tdingus@vtti.vt.edu
(540) 231–1501

Report Authors:
Dr. Hyeon-Shic Shin
Assistant Professor
City & Regional Planning
Morgan State University
Hyeonshic.shin@morgan.edu
(443) 885-3208

Michael Callow, Ph.D.
Professor, Department of Business Administration
Michael.callow@morgan.edu

Z. Andrew Farkas, Ph.D.
Director and Professor, National Transportation Center
Andrew.farkas@morgan.edu

Young-Jae Lee, Ph.D.
Associate Professor, Dept. of Transp. & Urban Infra. Studies
Youngjae.lee@morgan.edu

Seyedehsan Dadvar
Ph.D. student, Dept. of Transp. & Urban Infra. Studies
Seyedehsan.dadvar@morgan.edu

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Connected Vehicles/Infrastructure UTC

The mission statement of the Connected Vehicle/Infrastructure University Transportation Center (CVI-UTC) is to conduct research that will advance surface transportation through the application of innovative research and using connected-vehicle and infrastructure technologies to improve safety, state of good repair, economic competitiveness, livable communities, and environmental sustainability.

The goals of the Connected Vehicle/Infrastructure University Transportation Center (CVI-UTC) are:

- Increased understanding and awareness of transportation issues
- Improved body of knowledge
- Improved processes, techniques, and skills in addressing transportation issues
- Enlarged pool of trained transportation professionals
- Greater adoption of new technology

Abstract

The increased prevalence of Connected Vehicles (CVs) is expected to provide significant safety benefits to roadway users. Estimates indicate that the use of CVs will reduce non-impaired driver crashes by 80 percent. To ensure that the full benefits of CVs are realized, it is critical for transportation professionals to develop effective deployment strategies. However, the large number of unknowns currently makes this difficult. For instance, there are (1) no clear-cut deployment strategies due to a methodological void; (2) overly optimistic adoption estimates; and (3) no unified roadmaps to which state and local governments must conform. Current studies suggest that understanding drivers' perceptions, needs, and acceptance of CVs will provide rich information for solving these unknowns. As price is a serious barrier to CV technology proliferation, the primary goal of the current study is to use an adaptive choice-based conjoint analysis to estimate drivers' acceptance of and willingness to pay (WTP) for CVs through a simulation of participants' purchasing decisions. Results show that, with regard to the acceptance of safety features, acceptance of "collision warning packages" was the highest. Comparisons of WTP considering several socioeconomic variables found that drivers between the ages of 40 and 49 years, African-Americans, those with less than a bachelor's degree, and those with a higher budget for vehicle purchase were positively related to WTP. Results also indicate that, at every age, women are more concerned about safety than are men. While the study did not find statistical differences in WTP between men and women, women's budgets for vehicle purchases were lower than men's, and women reported significantly less prior knowledge of CVs. Also, women 50 and older appear less interested in CV technologies. As a result of these findings, the research team suggests that government agencies showcase CV technologies' safety benefits via media catering to mature women and at family-oriented public events.

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Introduction: Problem Statement

Recent and on-going vehicle technology innovations are shifting the driving paradigm. One such technology innovation involves the use of connected vehicles (CVs), which communicate with each other and the roadway via dedicated short-range communications (DSRC), exchanging information such as vehicle size, positions, speed, heading, lateral and longitudinal acceleration, etc. (Figure 1). Since the invention of the first car, drivers have been the sole decision makers when it comes to maneuvering their vehicles. However, the use of CV technology will eventually allow vehicles to partially or completely take over the drivers' roles. While autonomous/driverless vehicles are still in the development phase, CVs serve as an intermediate step to reach the full diffusion of autonomous vehicles, facilitating communications among both CVs and autonomous vehicles.

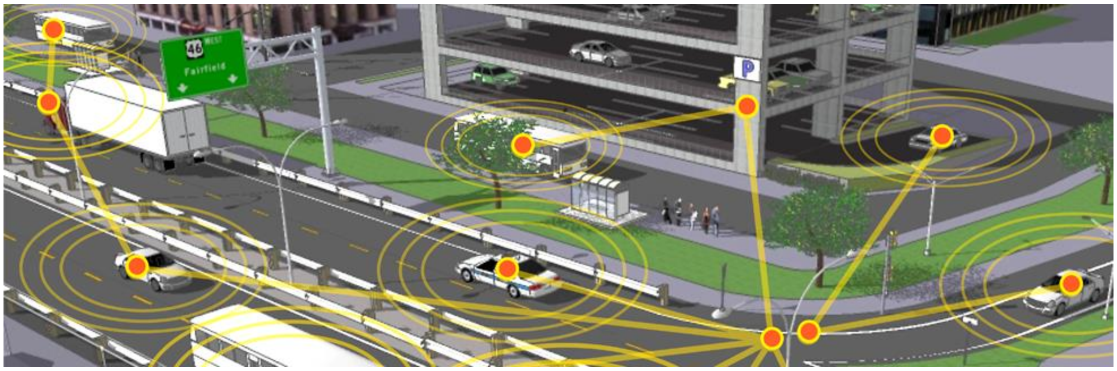


Figure 1. Interactions between CV and infrastructure [1].

As the great majority of crashes are caused by human error (often due to distracted driving caused by driver texting, phoning, eating, etc.), CVs are expected to provide significant safety benefits. Studies conducted estimate that CVs will reduce non-impaired driver crashes by 80 percent [2]. Such a reduction in crashes will also dramatically reduce nonrecurring traffic congestion, thereby improving travel time. A study conducted for the Washington State Department of Transportation found that nonrecurring congestion due to traffic accidents, weather, and work zones causes about 50 percent of the total traffic delay on highways [3]. A considerable reduction in crashes and traffic delay will result in huge social and economic cost savings. In recent years, the U.S. Department of Transportation (USDOT) has released several plans and rules for CVs. For example, on February 3, 2014, the National Highway Traffic Safety Administration (NHTSA) announced a plan to enable CV communication technology for light vehicles [4], and on August 18 of the same year, an advanced notice of proposed rulemaking to begin implementation of CV communication technology was released [5].

As to when CVs will be on the road in large numbers, a number of studies have suggested CV deployment timelines, but these projected timelines vary widely. One of the earliest studies including a CV deployment roadmap estimated that it would take six to nine years for CVs to constitute roughly 50 percent of the U.S. vehicle population and another 10 to 20 years for CV market saturation level to reach approximately 80 percent (a mature stage) [6]. A 2014 study by the American Association of State Highway and Transportation Officials (AASHTO) projected that the CV environment would reach a mature stage by 2040 [7]. A 2015 study by the Texas Transportation Institute anticipated that it would not be until 2050 that a critical mass of CVs is traveling on the road [8]. The range of estimation for a mature stage CV deployment is from about 20 to 35 years, which may be reasonable given evidence from the past. For example, anti-lock brake systems (ABS) were introduced in 1971 on the GM Cadillac and Chrysler Imperial models [6]. By 1994, 23 years later, about 60 percent of vehicles employed the system [6], with the adoption rate reaching its peak of about 75 percent in 2008 [9]. Note that ABS, which are not mandatory, never achieved a 100 percent adoption rate. The adoption of airbags, on the other hand, provides evidence that a government mandate may help rapid adoption of new vehicle technology. Airbags debuted in 1980, were made mandatory for all new vehicles in 1991, and their adoption rates reached 100 percent by 1996 [6].

Too Many Unknowns

A long transition period is likely for CV technology due to its complicated nature and associated unknowns. First, for example, there is no clear roadmap to future adoption. The aforementioned diffusion studies [6, 7, 8] were not based on scientifically sound methodologies; the projections were based solely on interviews with experts whose knowledge about CVs and their perceived acceptance was greater than that of the general public. Second, existing estimated CV market penetration rates [6, 7, 8] may be overly optimistic [10, 11]. Unlike past innovations, such as airbags and ABS, whose benefits are independent of other drivers' use, CVs' benefits can only be fully realized when CV technologies reach a certain level of market penetration. While early adopters may purchase a vehicle at the earlier stages, many drivers would wait until collective benefits become visible and CVs are on the road in large numbers. Third, an AASHTO study with USDOT revealed that state and local transportation agencies take actions independently [7]. A preferable alternative would be for unified USDOT-led strategies to be agreed upon and adopted across the U.S. All of the aforementioned unknown factors will slow down CV deployment, and this slow diffusion of CVs will make it complicated to manage a road network with mixed driver-operated and autonomous vehicles. Accordingly, major reductions in crashes will not occur until nearly all vehicles are connected.

Objectives of the Study

These unknowns can be addressed by understanding drivers' perceptions, needs, and acceptance of CVs. Several past studies have estimated drivers' acceptance of and willingness-to-pay (WTP) for CVs; however, these studies employed a direct question method, asking participants the amount they would be willing to pay [12, 13, 14]. A direct question method is an unreliable survey technique for understanding consumer behaviors in the market. Asking direct questions, such as "What CV features do you like, answer using Likert scale 1-5" and "How much are you willing to pay for CV?" cannot capture consumers' trade-offs when making a purchasing decision within their budget, during which they typically evaluate various aspects of alternatives and consider trade-offs for the best possible alternative [15]. Using a robust market simulation model to estimate divers' acceptance of and WTP for a CV was the primary goal of the current study. The study's objectives were to answer three questions in order to fill the gaps in current CV discussions:

1. What CV features do drivers prefer and how much are they willing to pay for a bundle of CV features of their choice?
2. Who are the early adopters and what are their characteristics?
3. What are the policy implications of various acceptance levels and WTPs stratified by socioeconomic characteristics?

Organization of the Report

The following chapter summarizes literature that provided theoretical backgrounds for this study. Next, there is a detailed description of the study's methodology—an adaptive choice-based conjoint survey and structural equation model—followed by discussions of the collected data, estimated driver acceptance, and WTP both at the aggregated level and stratified by survey participants' demographic characteristics. The report concludes with a summary of the study, providing policy suggestions, follow-up studies, and explaining the limitations of the study.

Literature Review

Theoretical Framework: New Technology and User Acceptance

Diffusion is defined as "the process by which an innovation is communicated through certain channels over time among members of a social system" [16]. There is general agreement within the field that most innovations experience an S-shaped rate of diffusion (Figure 2). Depending on the types of innovation, the slopes of the S-curves vary.

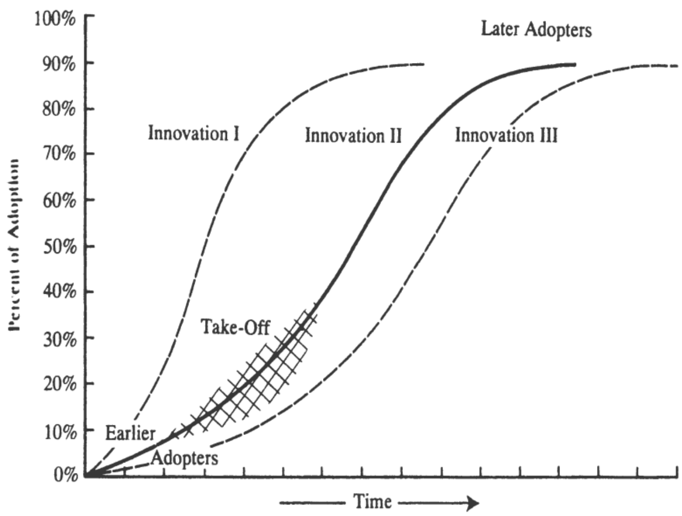


Figure 2. Diffusion of innovation [16]

The Bass diffusion model is particularly relevant to our study [17]. The Bass model points out that the adoption rate of a new product is shaped in part by the interaction between two types of adopters, namely innovators and imitators. Innovators are those who decide to adopt an innovation independently of others. They are "early adopters" who are willing to take risks, are affluent and young, and base their decisions on external information [16]. Imitators, also called "late adopters," are more likely to be influenced by the decisions of others (i.e., a contagion effect). The importance of innovators is greatest at the beginning of the diffusion process, but their importance diminishes over time. The imitation effect eventually takes over, leading to rapid diffusion rates, and has been described by a variety of terms, including "word of mouth," "contagion," and "interpersonal communication" [18]. Targeted marketing for and contagion through early adopters influence new product adoption rates [19, 20]. Therefore, it is important to examine peoples' innovativeness and socioeconomic characteristics to further distinguish early and late adopters.

The Technology Acceptance Model (TAM) is the most widely accepted diffusion model for explaining how users come to accept and use new technology [21, 22] The model is based on the theory of reasoned action, which proposes that behavioral intention mediates the relationship between attitude toward the behavior and actual behavior. TAM proposes that perceived usefulness and perceived ease-of-use are two attitudinal measures that help determine a potential user's attitude toward using the new technology. The TAM framework has been used extensively to explore the acceptance of new technologies, including the acceptance of cellular marketing [23], mobile TV service [24], 3G mobile value-added services [25], and handheld Internet devices [26]. This framework was expected to be useful for the purposes of this study in helping to identify the various attitudes and subjective norms that shape intentions to purchase vehicles with CV technology.

Drivers' Socioeconomic Characteristics and Technology Adoption

Socioeconomic characteristics are known as predictors of new product adoption and WTP. Consumer preference and WTP for technologies may also vary by gender. A survey of plug-in electric hybrid-vehicle acceptance revealed that women are less likely than men to adopt new technology, but have similar WTP [27]. Such difference may be justified by different attitudes toward risks and finance between males and females. In general, women are more risk averse and have different social preferences when making economic decisions; they are more sensitive to the price of the automobile than are men [11, 28, 29]. Nevertheless, women who are highly eco-conscious tend to be early adopters of electric vehicles [30]. This is probably because women are more conscious of fuel consumption and environmental impacts when buying vehicles [31]. Using a data set from a car ownership study in Toronto, Canada, gender differences in automobile ownership choices were modeled [32]. This study found that women preferred practicality, safety, and roominess in vehicles, while men preferred power and performance. Women were also more sensitive to the price of automobiles than men were. Women tended to rate safety similarly across the lifespan, while the importance of safety for male drivers increased with age [29]. In a survey of the acceptance of adaptive cruise control (ACC) systems, more male vehicle owners had such technologies than did women, but the numbers varied by age group and type of technology [33]. More females between ages 18 and 44 owned vehicles with reversing aids (backup warning and cameras) and adaptive cruise control than their male counterparts did [33]. Thus, women would likely accept CV technology as much or more than men, but their WTP for these kinds of technologies is unknown. Together, the safety and the environmental benefits of CVs may be attractive attributes to women but the additional cost may be a concern.

Consumer behavior research has found that consumers' product knowledge influences their purchasing decision [34]. This is because consumers' product-related evaluations (e.g., advantage, complexity, and risk) can positively or negatively affect their willingness to purchase the innovation [16, 35]. Product knowledge has two dimensions: familiarity and expertise [36]. Familiarity, sometimes referred to as usage experience, relates to the number of product-related experiences that the consumer has amassed over his or her lifetime [37]. Whereas one could argue that familiarity is not necessarily knowledge, it is assumed that knowledge is learned through repeated usage experience. In a similar vein, prior product knowledge has a direct impact on the rate and success of innovation adoption [35, 38]. That is, knowledgeable consumers tend to be more comfortable with processing a wide array of product information, while less knowledgeable consumers can be overwhelmed with the abundance of technical information relating to the product [39]. By the same token, the use and ownership of current technology are considered to be proxies of consumers' innovativeness [16, 40, 41].

An eminent study by Im, Bayus, and Mason [42] is worth mentioning; it tried to explain the complicated nature of people's behavior by employing structural equation modeling (SEM). Relationships among consumer characteristics and innate consumer innovativeness in new electronic purchasing were estimated in two phases. (A pictorial representation of a simplified model is presented in Figure 3). In the first stage, the main effects were examined: (1) personal characteristics as factors influencing new product adoption behavior (Path 1); (2) innate consumer innovativeness as an independent variable to estimate new product adoption behavior (Path 2); and (3) innate consumer innovativeness as a function of personal characteristics (Path 3). The second stage examined the moderating role of personal characteristics in explaining the link between innate consumer innovativeness and new product adoption behavior (Path 4). The study found that impacts from *income* and *age* on new product adoption behavior (i.e., Path 1) were statistically significant (confidence interval of 99 percent), whereas the impacts of *length of residence* and *education* showed weak relationships with new product adoption behavior. Impacts from innate consumer innovativeness to new product adoption behavior (i.e., Path 2) were also significant (confidence interval of 95 percent). The impacts from the last main effect, Path 3, were not significant at the 0.5 significance level. Finally, Path 4 was to examine the moderating role of personal characteristics between innate consumer innovativeness and new-product adoption behavior.

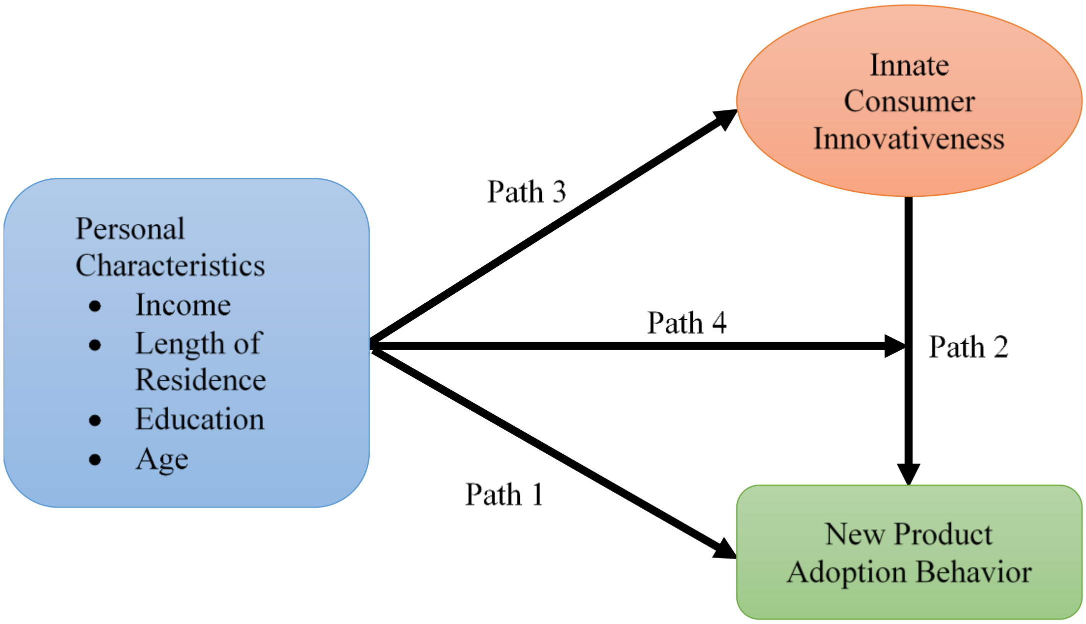


Figure 3. Model personal characteristics, innate consumer innovativeness, and new product adoption behavior [42].

User Acceptance and Willingness-to-pay

Acceptance of a product can be investigated by estimating consumers' preference or utility structure and WTP. Two analytical methods are widely used: observation-based methods (i.e., revealed preference [RP]) and survey-based methods (i.e., stated preference [SP]) [15]. An RP method uses historical market data or information collected by controlled experiments that mimic markets' designs. While rich data can be collected, this type of study is cost prohibitive. Moreover, new products with no established markets like CVs cannot be tested using RP methods. SP methods are classified into two categories: direct SP surveys and indirect SP surveys. The former involves asking marketing experts and/or potential consumers to indicate acceptable maximums and minimums. This is probably the mostly widely used method; all previous studies reviewed for this study [12, 14, 43, 44, 14] used direct SP surveys. However, this method cannot relate stated WTP to real purchase behavior since the direct questions cannot address consumers' purchasing behaviors in terms of evaluating trade-offs when choosing a number of alternatives [15]. The other category, indirect SP survey methods, includes conjoint analysis (CA) used extensively in marketing research. CA is known for its effectiveness in measuring preference structures of a new product with no historical data [45, 46]. Depending on specifications, a number of variations of

CA methods are available: traditional CA, adaptive CA (ACA), choice-based CA (CBCA) and adaptive choice-based conjoint analysis (ACBC).

While CA is probably new to most transportation researchers, the core of the method should not be foreign to transportation researchers. In particular, choice-based models such as CBCA and ACBC are built on random utility theory, which has been widely used in predicting travel demand, estimating drivers' value of time, and evaluating safety benefits [46]. The first use of CA in transportation research investigated the feasibility of adopting the E-ZPass system in the New York/New Jersey area in 1992 [45]. The study predicted a 38–50 percent adoption rate within 2 years; later it was found that the E-ZPass adoption rate reached 40 percent in the first six months of operation. The use of CA applications has increased in recent years. Lebeau et al. [47] employed CBCA to estimate market penetration rates for plug-in hybrid and battery electric vehicles in Belgium. Tanaka et al. [48] also used CBCA to compare American drivers' WTP for alternative fuel vehicles with that of Japanese drivers.

Despite its methodological rigorousness and robustness, CA applications have generally not been employed in transportation research, or for CV adoption studies, in particular. The Michigan Department of Transportation and the Center for Automotive Research (CAR) examined public perceptions and acceptance of CVs through direct SP survey methods [49]. Participants chose the safety benefits of CV technologies as most appealing compared to other CV features like mobility, traveler information, etc. Men and women had similar perceptions of the safety, mobility, and environmental benefits of CVs. Males were more concerned about security, driver distraction, complacency, and privacy than females were, while females seemed more sensitive to the cost of new onboard equipment technology. Another study using a direct SP survey approach was based on online surveys about CVs in the U.S., the UK, and Australia [14]. Participants' expectations for the technology were positive (66.4 percent), and over 40 percent of Americans were willing to pay about $500 to $1,500. A higher proportion (roughly 45 percent) did not want to pay extra for CV technology.

As part of the Connected Vehicle Safety Pilot Model Deployment, Driver Acceptance Clinics (DACs) were held in six locations between 2011 and 2012. During the DACs, participants were surveyed through a direct SP survey approach regarding acceptance and WTP [12]. Nearly 700 participants experienced a variety of vehicle-to-vehicle (V2V) applications from behind the wheel during a two-hour session. Following exposure, more than 90 percent of respondents expressed their desire to have this V2V safety feature on their personal vehicles. Participants were also asked to identify their WTP by answering a direct question with price examples: "At what price level might you begin to feel this collective group of safety applications (Vehicle-to-Vehicle communications safety feature) is too expensive to consider purchasing? (select one)." The answer options ranged from "More than $50" to "More than $250" in $50 increments. The study found that 91 percent of participants would spend up to $150, 79 percent would spend up to $200, and

58 percent would spend up to $250. However, over 60 percent of the participants answered that they would not buy CV applications until the diffusion rated reached at least 50 percent. While a large number of surveys were collected, this study did not consider consumers' trade-off behaviors when making purchasing decisions. Once bundles of different CV feature combinations with various price levels were provided to the participants, after 5–10 rounds of simulation survey, better acceptance and WTP was found. Note that this study's results were based on a survey of DAC participants who experienced V2V applications. In this sense, this study's reliability is greater than the aforementioned survey-based studies [14, 49].

A direct SP survey method is a convenient and low-cost approach to providing a broad picture of the surveyed topic. However, in addition to the lack of consideration of consumer purchase behavior, another direct SP survey method drawback is a result of the possibility of "social desirability bias." Social desirability bias is a major source of response distortion, as some respondents conceal their true desires and try to provide socially desirable answers [50]. However, indirect SP survey methods (e.g., CA surveys) are able to minimize errors resulting from this bias. An indirect method "realistically models day-to-day consumer decisions and has a reasonable ability to predict consumer behavior [51]." Similar studies suggested that "giving the respondents choice alternatives rather than direct questioning should make it easier for them to gauge their real preferences and actual value of alternatives" [52, 53]. Miller et al. [53] concluded that the type of product and purchasing context are among the important decision factors in WTP studies; indirect methods might be better suited for product categories with extensive decision process involvement (e.g., high price products such as computers, cell phones, digital cameras, etc.).

Breidert et al. [15] clearly summarized some of the potential flaws of direct SP surveying based on the literature and also their own observations as follows:

- Unnatural focus on price, which can affect the importance of other attributes of a product.
- No incentive for customers to reveal their true WTP. They might overstate prices because of prestige effects or understate prices because of consumer collaboration effects.
- Customers' valuations do not necessarily translate into real purchasing behavior.
- Direct WTP questioning for complex and unfamiliar goods [like CV] is a cognitively challenging task.
- Buyers often misjudge the price of a product, which can lead to an abrupt WTP change once the customer knows the market price of the product.

They concluded that the direct approach of asking WTP for different products does not seem to be reliable and restated previous controversial ideas such as Nagle and Holden's assertion that "the results of such studies [direct questions for WTP] are at best useless and are potentially highly misleading [54]." An empirical comparison of the two methods revealed that the indirect method provides a richer description of the attribute trade-offs that individuals are willing to make [55].

Study Methodology

This section discusses the techniques employed by the research team. First, an adaptive choice based conjoint (ACBC) survey and analysis were conducted to estimate drivers' acceptance of and WTP for CV technology bundles. To establish a hypothesis for the study's main method, a structural equation model revealing the characteristics of potential early adopters of CVs was built.

Adaptive Choice-Based Conjoint Analysis

ACBC analysis has been widely used for estimating people's acceptance (i.e., preference structure) of alternative product bundles and their WTP through a specially designed survey that simulates individual's trade-offs in making purchasing decisions [56]. To illustrate, consider a simple example of buying a new compact car (Table 1). One of the most important constraints for potential car buyers is price. Compact car buyers also highly value fuel economy and safety ratings. In other words, compact car buyers will compare at least three attributes: prices, fuel economy, and safety ratings. The data show that higher fuel economy and safety ratings are positively associated with the market price of a compact car. Assuming a buyer has a $28,000 budget allocated for purchasing a car, what car should the buyer purchase given three alternatives? Generally, a buyer would consider the initial importance of each attribute to him or her and settle on a compromise that would provide the highest level of satisfaction (i.e., utility).

Table 1. Buying a Compact Car

Attributes	Alternative A	Alternative B	Alternative C
Fuel economy	35 mpg	40 mpg	33 mpg
Safety rating	Good	Excellent	Good
Price	$27,000	$30,000	$24,500

The expansion of the above example in the ACBC frame allows researchers to identify the relative importance of product attributes as well as the most preferred product bundles of attributes. Relative importance is evaluated as part-worth utility scores that measure the contribution of a specific attribute to the total utility of an alternative extracted by a hierarchical Bayesian (HB) method at the aggregated and individual levels [57]. This method is particularly appropriate for estimating preferences and the WTP for "new products or products not yet on the market." Survey participants assessed ACBC surveys as being more engaging than conventional CA. ACBC surveys have lower standard errors, improve prediction of hold-out task choices, and provide better estimates of real-world product decisions [58].

An online survey was developed using Sawtooth Software's[1] SSI Web software and was divided into three sections. Since preferences and WTP are known to have associations with

[1] Sawtooth Software, Inc. is a computer software company based in Orem, Utah, USA. The company provides survey software tools and specializes in conjoint analysis (http://www.sawtoothsoftware.com/).

socioeconomic characteristics and innovativeness [27, 42], one section was added to the front and end of the survey. The first section consisted of questions on key socioeconomic characteristics (e.g., gender, age, and the number of adults and children under 18 in the household), last vehicle purchase or lease experience, research on safety features, current driving habits, and the level of technology in the driver's current vehicle. Drivers were also asked the extent to which various attributes—including safety, mobility, vehicle performance, and environmental concerns—would be important to them when purchasing a new vehicle. Drivers were then asked the degree to which they were familiar with the concept of CV technology. The second section focused on drivers' stated preferences for CV technology relating to safety and mobility. Drivers were first provided with a description of the different technology features. There were five attributes (Collision Package, Driver Assistance Package, Enhanced Safety Package, Roadway Information Package, and Travel Assistance Package) that included nine safety features and two mobility features (Table 2); the details of the selected CV attributes of are available in Appendix B. It should be noted that technologies and attributes were selected and grouped after a comprehensive technology review. Many other, somewhat similar, technologies that have been or are being developed were not included in the survey. A brief description and a picture of each attribute were provided to participants at the beginning of the second section. An example is provided in Figure 4. Then, drivers were asked to configure their own preferred bundle of attributes in the "build your own" (BYO) section (Figure 5). BYO is the basis for the ACBC survey to obtain each participant's initial preferences for alternatives, which enables the survey software to compose a relevant set of attribute levels for the third section—"screener." In the screener section, four CV technology bundles with prices were presented on each page. Progressing through a series, the respondent had to choose bundles that were "Unacceptable" or "Must Have" so that the consistency of responses could be assessed.

The information collected from the screeners became input for the last section, the choice tournament. Technology bundles tailored for each respondent were presented, three bundles at a time. Bundles identified as "Possibilities" during the screener section were carried forward to the choice tournament. To reduce the complexity of the choices, attribute levels that were constant across the bundles were grayed out (Figure 6). The winning concept from each tournament moved on to subsequent tournaments, and the choice tournament proceeded until the most preferred bundle was determined and WTP was estimated. The survey ended with additional questions on demographics.

Price estimates were made based on modifying the existing technology prices of leading auto manufacturers such as Audi, BMW, Cadillac, Chevrolet, Lexus, Mercedes-Benz, Porsche, Toyota, and Volvo with V2V and V2I features, requirements, and enhancements with sensors. In the BYO section, prices varied depending on the choice level of the participants ($0 to $1,100 for the Collision Package, $0 to $1,200 for the Driver Assistance Package, $0 to $1,000 for the Enhanced Safety Package, $0 to $500 for the Roadway Information Package, $0 to $700 for the Travel

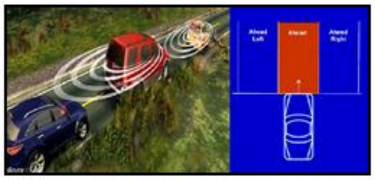
Assistance Package, and finally \$0 to \$4,500 for the total price). However, a ±30 percent change in BYO prices was applied during the ACBC screening choice questions to resemble the variations in the actual WTP of participants. This adjustment was done based on Sawtooth Software recommendations, and it allowed the utility of non-price attributes to be interpreted independently from those associated with price increments [59]. Details of price estimation for selected CV attributes and features are provided in Appendix C. The online survey flyer and also snapshots are available in Appendix D and Appendix E, respectively.

Table 2. CV Technology Choice Attributes

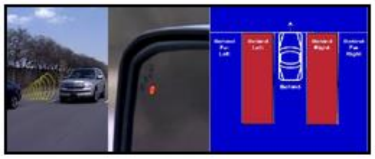
Attributes	Levels	CV Technologies
Collision Package	1	None
	2	Front Collision Warning
	3	Side Collision Warning
	4	Front & Side Collision Warning
	5	All-Around Collision Warning
Driver Assistance Package	1	None
	2	Lane Departure System
	3	Intersection & Left-Turn Assist
	4	Lane Departure System; Intersection & Left-Turn Assist
Enhanced Safety Package	1	None
	2	Do-Not-Pass Warning
	3	Pedestrian & Cyclist Alert
	4	Do-Not-Pass Warning; Pedestrian & Cyclist Alert
Roadway Information Package	1	None
	2	Road Condition Notification
	3	Slow/Stop/Wrong-Way Vehicle Advisor
	4	Road Condition Notification; Slow/Stop Wrong-Way Vehicle Advisor
Travel Assistance Package	1	None
	2	Real Time Travel Planning & Route Optimization
	3	Parking Spot Locator
	4	Real Time Travel Planning & Route Optimization; Parking Spot Locator

COLLISION PACKAGE

Front Collision Warning: An electronic system that enhances safety by monitoring the roadway in front of the vehicle and warning the driver when a potential collision risk exists.



Side Collision Warning: An electronic system that enhances safety by monitoring the lanes adjacent to the vehicle to detect moving and stationary objects within the side blind spots. The system provides warnings to drivers of possible collisions with vehicles traveling in an adjacent lane.



All-Around Collision Warning: An electronic system that enhances safety by monitoring the roadway in front, to the side, and behind the vehicle and warning the driver when a potential collision risk exists.

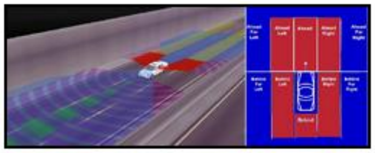
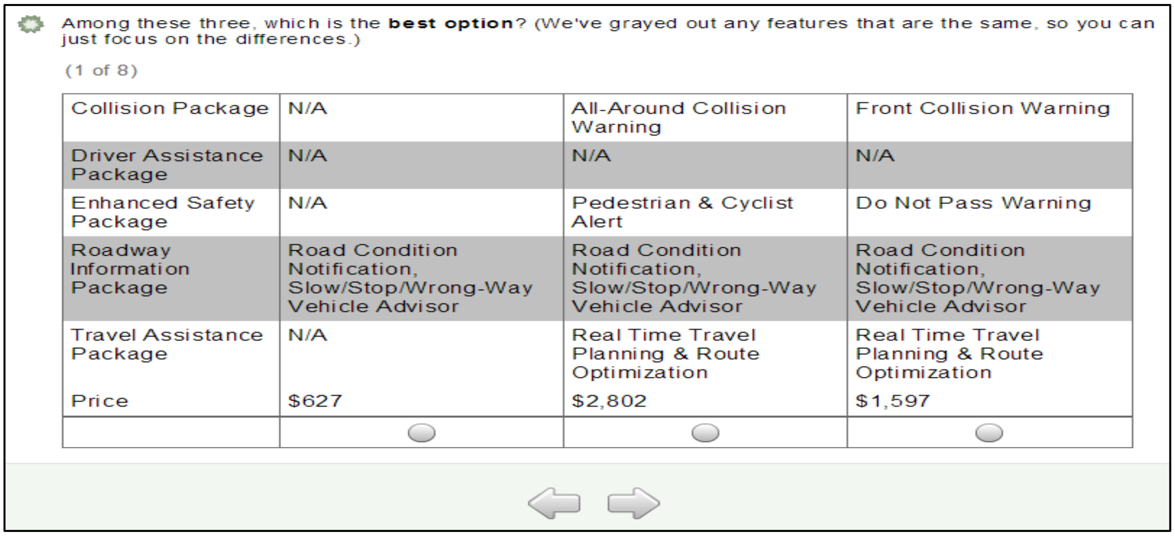


Figure 4. Example of attribute descriptions and video clips.

Please select the attributes you'd most likely include in your next vehicle. For each feature, selec your preferred level.

Attribute	Select Feature	Cost for Feature
Collision Package	Front & Side Collision Warning (+ $900)	$ 900
Driver Assistance Package	N/A	$ 0
Enhanced Safety Package	Do Not Pass Warning (+ $300) Select Feature N/A Do Not Pass Warning (+ $300) Pedestrian & Cyclist Alert (+ $750) Do Not Pass Warning, Pedestrian & Cyclist Alert (+ $1,000)	$ 300
Roadway Information Package	[illegible]	$ 500
Travel Assistance Package	[illegible]	$ 500
	Total	$ 2,200

Figure 5. BYO task.



Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(1 of 8)

Collision Package	N/A	All-Around Collision Warning	Front Collision Warning
Driver Assistance Package	N/A	N/A	N/A
Enhanced Safety Package	N/A	Pedestrian & Cyclist Alert	Do Not Pass Warning
Roadway Information Package	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	N/A	Real Time Travel Planning & Route Optimization	Real Time Travel Planning & Route Optimization
Price	$627	$2,802	$1,597

Figure 6. Choice tournament task.

Before being administered, the survey questionnaire was reviewed by the technical advisory committee formed for the study. Then, the revised survey was administered to a small pilot group to obtain feedback. The test showed that respondents focused on the safety benefits, costs and convenience of CVs. There was concern by some respondents over the questionnaire's length. However, the survey length remained the same because of a high completion rate; nearly 52 percent of the participants in the pilot completed the survey. A high response rate confirmed past studies' findings on a high level of engagement in ACBC surveys [60]. After further revision, the survey was posted online.

Two recruitment strategies were employed. First, the survey was promoted to personal contacts and mailing lists of the study team's research community. Second, survey recruitment advertisements were posted on Craigslist and Backpage, and a dedicated Facebook page was opened. In the recruitment letter, participants were asked to recommend the survey to others whom they knew (i.e., snowball sampling). Given the difficulty in drawing a random sample through this type of survey, this was the best non-random sampling method to increase participants with relative ease [61]. The survey was available for approximately 6.5 months, from September 26, 2013, to April 16, 2014.

The long and complex survey was engaging and accepted very well by the participants, confirming past studies' findings [58, 60, 62]. Nearly 43 percent of the individuals (611 of 1,432) who accessed the survey site completed the survey. The time taken for the completed surveys varied wildly, ranging from 2.95 minutes to about 12 days and 20 hours. Following past studies on online survey data quality assessment [63, 64, 65, 66, 67, 68], responses with an unusually short elapsed time (beyond ± one standard deviation of the mean) were removed. The final research data set included 529 usable surveys (36.9 percent of the total participants). Although the participants were not drawn by random sampling, the collected data were largely representative of the U.S. population.

Structural Equation Model

SEM is a useful tool to test theories and hypotheses. It guides researchers in discerning relationships when both a measurement model and a structural model are involved. Variables that are actual items measured directly using surveys, observations, or some other measurement devices are used to build measurement models. Constructs that are unobservable or latent factors that are represented by a variate that consists of multiple variables are used to build structural models [69]. The general format of a structural equation model can be represented by the following matrix equations [69, 70, 71]:

$$\boldsymbol{\eta}_{(m*1)} = \boldsymbol{B}_{(m*m)} \times \boldsymbol{\eta}_{(m*1)} + \boldsymbol{\Gamma}_{(m*n)} \times \boldsymbol{\xi}_{(n*1)} + \boldsymbol{\zeta}_{(m*1)} \tag{1}$$

$$\boldsymbol{Y}_{(p*1)} = \boldsymbol{\Lambda}_{Y(p*m)} \times \boldsymbol{\eta}_{(m*1)} + \boldsymbol{\varepsilon}_{(p*1)} \tag{2}$$

$$\boldsymbol{X}_{(q*1)} = \boldsymbol{\Lambda}_{X(q*n)} \times \boldsymbol{\xi}_{(n*1)} + \boldsymbol{\delta}_{(q*1)} \tag{3}$$

where:

η – A construct associated with measured **Y** variables (endogenous).

B – A way of referring to the entire set of **β** relationships for a given model, in which **β** is a path representing a causal relationship (regression coefficient) from one **η** construct to another **η** construct.

Γ – A way of referring to the entire set of **γ** relationships for a given model, in which **γ** is a path representing a causal relationship (regression coefficient) from a **ξ** to an **η**.

ξ – A construct associated with measured **X** variables (exogenous).

ζ – A way of capturing the covariation between **η** construct errors.

Λ – A way of referring to a set of loading estimates represented in a matrix where rows represent measured variables (either **X** or **Y**) and columns represent latent constructs (either **ξ** or **η**).

X – A measured variable (exogenous).

Y – A measured variable (endogenous).

ε– The error term associated with an estimated, measured **Y** variable.

$\boldsymbol{\delta}$ – The error term associated with an estimated, measured **X** variable.

The key variables of interest in SEM are "latent constructs" because their behavior can only be observed indirectly through their effects on measured variables. A structural equation model may include two types of latent constructs: endogenous (indicated by $\boldsymbol{\eta}$) and exogenous (indicated by ξ). These two types of constructs are distinguished based on their dependency in the model equations. Endogenous constructs are dependent in at least one equation (one or more arrows lead into them). Exogenous constructs are independent in all equations in which they appear and they are determined by factors outside of the model.

In SEM, coefficients of constructs are represented in two matrices: **B** and $\boldsymbol{\Gamma}$. The elements of the former represent causal effects of endogenous constructs on other endogenous constructs. The elements of the latter represent causal effects of exogenous constructs on endogenous constructs. The vector $\boldsymbol{\zeta}$ is a random vector of residuals that is a structural error term. Exogenous and endogenous constructs are associated with the **X** and **Y** measured variables, respectively. There is no difference between measured variables and their association with constructs. The two vectors of $\boldsymbol{\delta}$ and $\boldsymbol{\varepsilon}$ are errors of measurement in **X** and **Y**, respectively. The two matrices of $\boldsymbol{\Lambda}_\mathbf{X}$ and $\boldsymbol{\Lambda}_\mathbf{Y}$ are regression matrices of **X** on $\boldsymbol{\xi}$ and of **Y** on $\boldsymbol{\eta}$, respectively [70].

Implementation of the structural equation model consists of six stages [69]:

1. Define the individual constructs and identify items to be used as measured variables.
2. Develop and specify the measurement model including the path diagram.
3. Design a study to produce empirical results.
4. Assess measurement model validity by assessment of line goodness-of-fit (GOF) and construct validity of measurement model.
5. Specify a structural model by converting the measurement model to a structural model.
6. Assess structural model validity by assessing GOF and significance, direction, and size of structural parameter estimates.

The basic SEM fit statistic is the χ^2 statistic; however, researchers have developed many different fit indices that represent the GOF of a structural equation model in different ways [69]:

$$\boldsymbol{GFI = 1 - \frac{F_k}{F_0}} \tag{4}$$

where GFI is the goodness-of-fit index, F_k is the minimum fit function after a structural equation model has been estimated using k degrees of freedom, and F_0 is the fit function that would result if all parameters were zero.

The smaller the ratio of $\mathbf{F_k/F_0}$, the better the fit. With that said, usually a value of at least 0.90 for fit indices is required to accept a model.

$$\boldsymbol{RMSEA} = \sqrt{\frac{(\boldsymbol{X^2 - df_k})}{(\boldsymbol{N-1})}} \quad (5)$$

where RMSEA is the root mean squared error of approximation and N is the sample size.

The smaller the value of RMSEA, the better the fit. Typically, a value less than or close to 0.05 is required.

$$\boldsymbol{CFI} = \boldsymbol{1} - \frac{(\boldsymbol{X_k^2 - df})}{(\boldsymbol{X_N^2 - df_N})} \quad (6)$$

where CFI is the comparative fit index.

Higher values of CFI indicate better fit. For a perfect fit, this fit index should be as close as possible to 1.0.

We tried to identify possible structures of the collected data to construct the study hypothesis. To this end, an exploratory factor analysis was conducted. It is a data reduction technique widely used to identify a small number of common characteristics (i.e., factors) "underlying a relatively large set of variables [72]." It is particularly useful when no predefined relationships or theories on the subject are available, which is the case for CV adoption behaviors. This task was carried out using IBM SPSS 22.

Data Compilation and Quality Assessment

A total of 1,432 individuals from 50 states and the District of Columbia accessed the survey link and 743 respondents (51.9 percent) completed the survey; however, further data cleaning decreased the number to 611 completed and valid surveys (42.7 percent). The reduction was due to the removal of all participants who did not select anything during the tournament sections of the survey or just selected one or two, causing their final tournament prices to be calculated based on Sawtooth estimations. Considering the length of the survey (52 questions, three pages of CV technology descriptions, and a series of choice exercises), a high completion rate implies that the survey was successfully designed to engage respondents. Recruiting through social media attracted the majority of participants (75 percent) (Table 3). The average cost per usable survey was $6.60, which is slightly higher than a similar effort ($4.28) by Ramo and Prochaska [73]. A detailed data dictionary for the survey is provided in Appendix F. Also, the results of a reliability test for some purchasing involvement questions are presented in Appendix G to validate the data.

A further examination of the responses revealed that some surveys were completed in a very short time, raising questions about the data quality. One strategy is to examine if a respondent selects the same answer category for all items, which is the case when a survey is too long [63]. No clear evidence of less serious responses was found from the current survey. Another strategy is to examine responses with a short elapsed time. A long elapsed time may imply that the participant was interrupted during the survey and came back later to complete it. However, an unusually short elapsed time needs to be scrutinized since the shorter elapsed time is related to potentially poor data quality [64]. The time taken for the 611 surveys varied wildly, ranging from 2.95 minutes to 18,465.20 minutes (roughly 12 days and 20 hours). According to the pilot test, the survey cannot possibly be completed in less than 10 to 15 minutes. The completion time was transformed by taking the natural logs of time values to account for an extreme skewness of the distribution [65]. First, the very large values were temporarily removed from the data set to avoid a strong influence of large values in finding surveys with short elapsed time. The data set without very large values formed a normal distribution. Second, extremely small values were removed. Values smaller than the mean minus one standard deviation of the elapsed time were considered outliers [67], leaving responses with elapsed time longer than 10 minutes. Responses with very long elapsed time were then added back to the cleaned data set, leaving 529 usable surveys in the final data set (36.9 percent of the total participants).

Participant Characteristics

Although the participants were not drawn by random sampling, the collected data were largely representative of the U.S. population. A summary of selected socioeconomic variables is presented in Table 3. Gender was balanced, with 51.2 percent male and 48.5 percent female respondents, which is not much different from the national average (male 49.2 percent and female 50.8 percent) [74]. The age distribution was also similar to the national statistics. As to race/ethnicity, African-Americans were somewhat overrepresented by about five percent compared to the national average. The overrepresentation of African-Americans might be due in part to the recruitment method. Faculty, staff, and students of Morgan State University were included on one of the emailing lists. As it is one of the historically black colleges and universities, African-Americans account for a larger proportion of the community. Of all survey participants, 61.5 percent had earned at least a bachelor’s degree. This is much higher than the national average of 22.8 percent [74]. Again, this was due to the recruitment method: many participants were from the authors’ colleagues in various academic institutions. While the higher income group was about two percent over-represented compared to national statistics [74], the distributions of demographic characteristics were generally similar to the national statistics, making the collected data relatively representative.

Table 3. Summary of Participants' Characteristics

Demographic Characteristics		Count	Percent
Gender	Male	271	51.2
	Female	258	48.8
Age	Younger than 30	113	21.4
	30-39	114	21.6
	40-49	121	22.9
	50-59	113	21.4
	60 and older	68	12.9
Race/ethnicity	White (Non-Hispanic)	345	65.6
	Hispanic	27	5.1
	Black/African-American	91	17.3
	Asian	31	5.9
	American Indian/Alaska Native	9	1.7
	Native Hawaiian/other Pacific Islander	3	0.6
	Other	20	3.8
Education	Associate degree and lower	202	38.5
	Bachelor's degree	167	31.9
	Master's degree	102	19.5
	Doctoral or postdoctoral degree	53	10.1
Household annual income	Less than 50K	186	36.1
	50K-100K	167	32.4
	More than 100K	162	31.5
Current vehicle type	Sedan or coupe	230	44.4
	SUV	109	21.0
	Truck	37	7.1
	Minivan	28	5.4
	Luxury vehicle	17	3.3
	Station wagon	25	4.8
	Convertible	9	1.7
	Van	4	0.8
	Crossover	23	4.4
	Sports car	11	2.1
	Other	24	4.6
	Not sure	1	0.2

N = 529

Analysis and Findings

This section discusses the survey analysis generated by the ACBC survey software. Drivers' preferences are analyzed by attribute levels and relative importance of attributes. Then estimated WTP is presented at the aggregated level. Also, the relationships between WTP and socioeconomic characteristics and measured driver innovativeness are discussed. Structural equation modeling results show causal relationships between variables and WTP and bundle choices. Finally, word clouds were drawn for open-ended questions using Wordle [80].

Preferences by Attribute Levels

Mean utilities by attribute levels are presented in Table 4, which was generated by the survey software based on ACBC simulations. They are scaled to sum to zero within each attribute. A negative utility is not indicative of a particular technology's unattractiveness; rather, it means the technology is relatively less attractive than others. For example, although the utility of "No collision package" was negative, that package would have been acceptable to some respondents. But, all else being equal, "Front & side collision warning" and "All collision packages" were more attractive than "No collision package." It is clear that participants preferred to have some CV technologies given that the "No package" level of each attribute received the lowest scores. For all attributes, the most comprehensive packages received the highest utilities, also implying high acceptance level. Should drivers buy a package, they would rather buy the most comprehensive package. However, their preferences and potential purchase decisions are likely to be constrained by price levels. As package prices (summed prices) increased, utilities decreased sharply from 132.52 to 3.89 and to −126.89. That is, participants' utilities were highly sensitive to the changes in prices. A series of analysis of variance (ANOVA) tests did not support gender difference in preferences with one exception: the "Pedestrian & cyclist alert," $F(1, 527) = 3.947$, $p = 0.047$.

Table 4. Mean Utility by Attribute Levels

Attributes	Levels	CV Technologies	Total
Collision Package	1	No collision package	-39.84
	2	Front collision warning	-.93
	3	Side collision warning	-8.64
	4	Front & side collision warning	11.73
	5	All collision package	37.68
Driver Assistance Package	1	No driver assistance package	-14.53
	2	Lane departure system	7.12
	3	Intersection & left turn assist	-3.72
	4	All driver assistance package	11.13
Enhanced Safety Package	1	No enhanced safety package	-16.27
	2	Do not pass warning	-1.87
	3	Pedestrian & cyclist alert	4.33
	4	All enhanced safety package	13.81
Roadway Information Package	1	No roadway information package	-11.60
	2	Road condition notification	5.56
	3	Slow/stop/wrong-way vehicle advisor	-5.76
	4	All roadway information package	11.81
Travel Assistance Package	1	No travel assistance package	-10.91
	2	Real time travel planning & route optimization	7.93
	3	Parking spot locator	-9.85
	4	All travel assistance package	12.83
Summed Price	Utility for Price: $0		132.54
	Utility for Price: $1,398		43.97
	Utility for Price: $2,520		3.89
	Utility for Price: $3,727		-53.51
	Utility for Price: $5,850		-126.89
Mean Utility			97.38

Relative Importance of Attributes

The relative importance is the average of all ratios of the individual importance scores to the total individual importance scores and is calculated by dividing the range of utilities of an attribute by the sum of all ranges. The importance scores reveal "how much difference each attribute could make in the total utility of a product [58]." The larger the range of utilities within an attribute, the greater the relative importance of the attribute becomes. Participants considered package price the most important because it has the largest utility range (Figure 7). For CV technologies, "Collision Package" received the highest average importance score, followed by "Travel Assistance

Package." Gender difference was tested using a t-test; however, the difference was not statistically significant at 0.05 significance level.

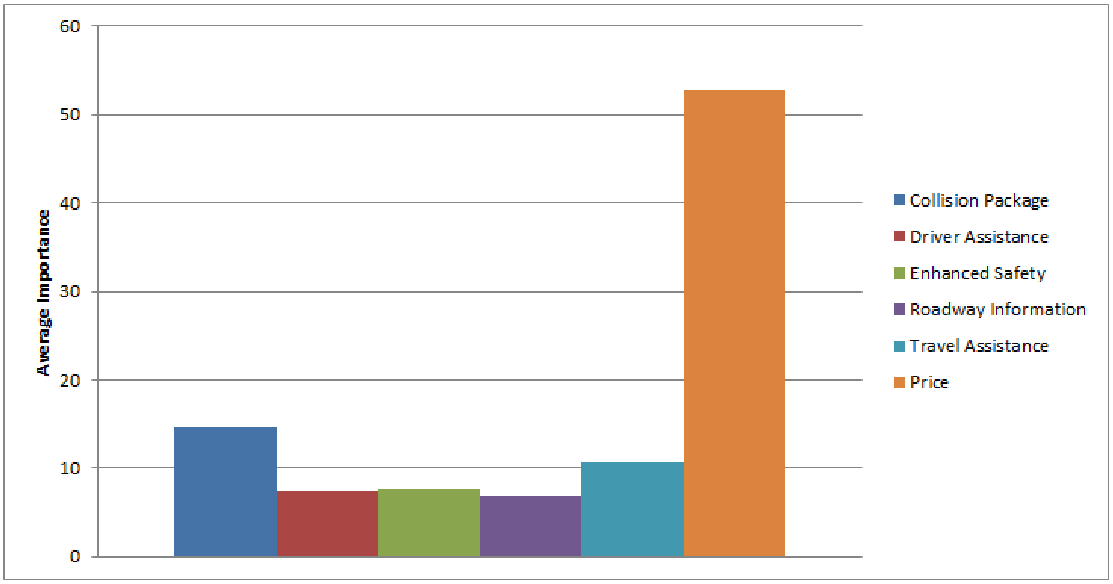


Figure 7. Average importance scores of attributes.

Willingness-to-pay

After a series of choice tournaments with various bundles and prices, the winning price (in terms of WTP) for each respondent was estimated. The mean WTP was $2,157 with a standard deviation of $1,072 and a median of $1,984. One respondent did not want to pay extra for CV technologies (i.e., zero WTP). The maximum WTP was $5,469. It should be noted that the comparison of the relative differences in WTP among variables of interest is the primary focus, not absolute values. While the prices were estimated on the basis of a comprehensive technology review, the nominal WTP may be misleading. The values of technology change over time due to inflation or deflation, a decrease in technology costs, and competition. In contrast, the differences of WTP may not change.

The comparison of BYO prices and WTP highlights the advantage of the ACBC analysis over direct question-based studies (Figure 8). In the BYO section, participants answered that they were willing to pay $2,304 on average. After a series of screener tasks and choice tournaments, their WTP decreased by 6 percent to $2,157 from their BYO prices. The difference was statistically significant, $t(528) = 3.510$, $p < 0.001$. This implies that the ACBC analysis reflects consumers' purchasing behavior in a real market. That is, consumers make decisions after contemplating trade-offs of various factors, such as the prices of attribute levels, the availability of desirable bundles, income, and other monetary conditions. This finding clearly illustrates why WTP measured by asking "how much are you willing to pay for this bundle?" is likely to be misleading.

This analysis also found that women seemingly were more sensitive to price and more risk averse than men, confirming past studies [28]. As shown in the figure, men's BYO and WTP were higher than women's BYO and WTP. Of interest from the comparison between BYO and WTP is that the WTP rates for the totality of the participants, male and female, are lower than the BYO rates, a statistically significant finding at a 99 percent confidence interval. This observation reveals the advantage of an ACBC survey, one of the indirect SP survey types. As described in the Study Methodology section and shown in Figure 5, BYO obtains the participant's initial preference structure, similar to a direct SP survey—for example, *"What CV features would you like to choose and how much are you willing to pay for the chosen features?* As noted earlier, the purpose of the BYO was to obtain input on participants' initial preferences. Then, after a series of screener sections, estimated WTP rate results show levels of WTP after participants considered a variety of CV attributes and features bundles.

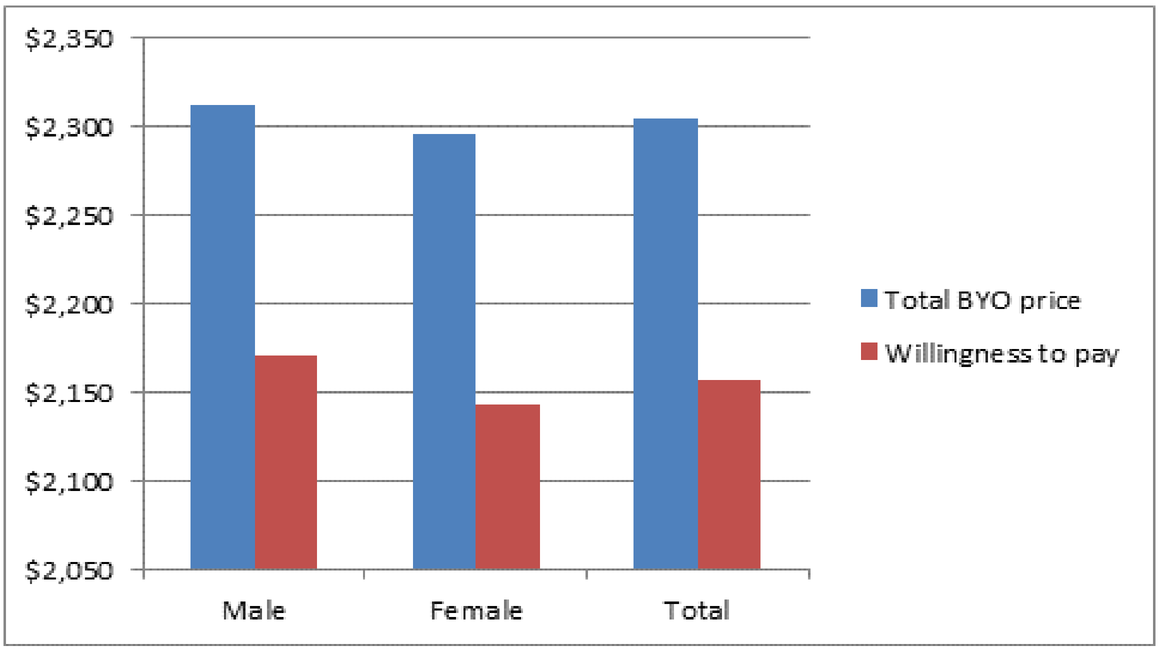


Figure 8. Mean build-your-own and WTP.

WTP and Preferences by Demographic Characteristics

Demographic characteristics are related to people's preferences and WTP [11, 28, 29]. To examine relationships among variables, a series of one-way ANOVAs were performed (Table 5). The table also presents statistically significant relationships in different colors, at $p \leq 0.1$, $p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$, and with positive or negative signs to reflect a positive or negative association with the dependent variable.

Gender

While no statistically significant gender difference in WTP exists, men and women had much different preferences in purchasing vehicles. Conforming to past studies [27, 30], results showed that women were more conscious about safety, fuel consumption, and environmental impact, and considered reliability an important decision factor. On the other hand, several factors, such as exterior design, motor power, status, and driving comfort, were more favored by men, although the differences between men's and women's preferences were not statistically significant.

Age

WTP values varied by age. Individuals between 40 and 49 years old would pay the highest amount ($2,297), followed by the 30–39 age group ($2,276). The WTP of those 60 years and older was the lowest ($1,966), very similar to participants under 30 years old. While younger individuals are generally known to be early adopters of new technology, in the case of WTP the middle age group (40–49 years old) could be early adopters. Income and budget levels probably play an important role, since many participants in younger age groups are likely students or in their early careers.

Race

Race/ethnicity seemed to influence WTP and preference. Compared to other races and ethnicities, African-Americans considered most vehicle purchase factors important except for reliability and environmental performance. In addition, they were willing to pay more than others. Except for Native Hawaiians and American Indians, whose sample sizes were too small, African-Americans' WTP was the highest ($2,481), 15 percent higher than the average WTP ($2,157), and 20 percent more than whites' WTP ($2,068).

Education

Respondents with less than a bachelor's degree would pay more than those with higher degrees. Interestingly, WTP decreased with additional educational attainment: WTP was $2,232 for individuals with less than a bachelor's degree, $2,169 for those with a bachelor's degree, $2,169 for those with a master's degree, and $1,985 for those with a doctoral degree. The inverse relationships between WTP and education level are somewhat counter-intuitive, since education levels are generally correlated with income.

Income and Budget

Middle-income households were willing to pay the highest ($2,255) for CV technology, followed by the high-income and low-income households. However, the differences were small and statistically insignificant. All else being equal, participants had a similar level of acceptance of the CV technologies regardless of their income level. However, budget levels were positively related to WTP. Thus, it can be inferred that WTP is not a simple function of income; rather, it is determined by some interactions among variables. As expected, the high-income group prefers attractive exterior design and driving comfort compared to middle- and low-income groups.

CV Knowledge and Innovativeness

Early adopters of new technology tend to know more about technology and they are innovators who are willing to take risks. To identify early adopters, we asked two questions that are related to knowledge and innovativeness. First, participants were asked to provide their knowledge level of CV technologies. Four choices were given: (a) never heard of; (b) heard of it, but don't understand; (c) limited knowledge; and (d) knowledgeable. The second question was about the innovativeness of respondents, similar to past studies [42]. Participants were asked to provide the number of onboard features available in their current personal vehicles, assuming a positive association between onboard feature selection and innovativeness. The features considered were in-vehicle navigation, hands-free calling, hybrid/electric engine, parking assistance, back-up warning system, lane departure warning system, video entertainment system, and satellite/HD radio. As expected, knowledge of CVs was related to WTP. Those who were knowledgeable about CV technologies were willing to pay 10.9 percent more than respondents with no CV knowledge ($2,253 vs. $2,032). As to innovativeness, respondents with higher innovativeness were willing to pay more than other cohorts. The WTP of individuals with high innovativeness ($2,845) was roughly 29 percent ($639) and 52.5 percent ($979) higher than those with medium or low innovativeness, respectively.

Table 5. ANOVA of Demographic Variables, CV Knowledge, and Innovativeness

Question	Variables	Gender (Female)	Age < 30	Age 30-39	Age 40-49	Age 50-59	Age 60+	Race (Black)	Education (less than bachelor's)	HH income (high)	Budget	No CV knowledge	Innovativeness
Factors important for vehicle purchase	Safety	+	–					+	–				+
	Exterior design						–	+		+			+
	Motor power		–		+		–	+	–				+
	Status		+	+		–	–	+					+
	Driving comfort		–					+		+			+
	Inside space	+	–					+					+
	Fuel consumption	+						+					
	Reliability	+	–				+	–					
	Environment	+	–			+			–				
Knowledge on CV		+							–				+
Collision Package	None												–
	Front collision warning												–
	Side collision warning						–						
	Front & side collision warning		+										
	All collision package		–	+									–
Driver Assistance Package	None		+					–	–				–
	Lane departure system									–			
	Intersection & left turn assist				+		–						
	All driver assistance package							+	+	–			+
Enhanced Safety Package	None												–
	Do not pass warning			–		+			+	–			
	Pedestrian & cyclist alert	–											
	All enhanced safety package		–							+			+
Roadway Information Package	None									+			
	Road condition notification		+		–					–			
	Slow/stop/wrong-way vehicle advisor												
	All roadway information package				+	–				+			
Travel Assistance Package	None		–		–		+						
	Real time travel planning & route optimization				+	–							–
	Parking spot locator						–						
	All travel assistance package		–		–								+
Willingness-to-Pay			–		+		–	+	+		+	–	+

Legend: $p \leq .1$; $p \leq .05$; $p \leq .01$; $p \leq .001$

Structural Equation Modeling Results

The purpose of using SEM was to examine the influence of socioeconomic characteristics and innovativeness on drivers' choices and WTP. SEM is known as a useful tool for hypothesis testing and theory building [69]. The previous sections showed various relationships between surveyed variables, acceptance, and WTP. However, these relationships are limited to one-to-one comparisons. Using the various variables collected from the survey allows for the measurement of relationships among variables, leading to more insightful and refined results.

Table 6 shows the results of the exploratory factor analysis, the purpose of which was to reduce several dozens of choice bundles to a manageable number of factors. In this case, five factors with eigenvalues higher than 1.0 were selected for future analysis. Eigenvalue 1.0 is the minimum threshold for forming meaningful factors. Among all available rotation methods, varimax rotation produced a clear factor structure, as shown in Table 6. The values in the cells are factor loadings ranging between −1 and +1, with +1 implying positive association with the factor and zero meaning no relationship. Using .40 as a cut-off loading value, variables were grouped by factor. Factor 1 includes four variables relevant to current in-vehicle safety technologies used by drivers. Factor 2 includes four in-vehicle technologies related to driving information and entertainment. Together, Factors 1 and 2 are about current use and ownership of technologies by participants, an indirect measure of innovativeness [16, 40, 41]. The third and fourth factors indicate vehicle characteristics that drivers consider most important for purchasing decisions: safety and comfort, and status and motor power, respectively. The fifth factor consists of vehicle characteristics and technology related to the environment.

Table 6 Identified Factors after Varimax Rotation

	Factor				
	1	2	3	4	5
Diff4_ParkAssist_R Parking Assist	.751	.104	-.066	.177	.085
Diff5_BackupWarm_R Back Up Warning	.746	.225	.080	.042	-.040
Diff7_LaneDepWarm_R Lane Departure	.636	.138	.085	.144	.032
Diff6_BackupCam_R Back Up Camera	.598	.381	.055	.023	.032
Diff9_SatHDRadio_R Satellite/HD radio	.137	.658	.031	.180	.007
Diff2_Handsfree_R Hands-free	.186	.619	.126	.058	-.019
Diff1_Navigation_R Navigation	.306	.564	.042	.151	-.052
Diff8_VideoEnt_R Video Entertainment	.355	.402	-.018	.309	.052
CarChar5_DrivingComf_R Driving comfort	.058	.118	.703	.256	.007
CarChar6_InSpace_R Interior space	.028	.100	.620	.277	.096
CarChar8_Reliability_R Reliability	-.034	.007	.456	-.026	.180
CarChar1_Safety_R Safety	.114	.003	.429	.065	.326
CarChar4_Status_R Status	.180	.046	.049	.653	.058
CarChar3_MtrPwr_R Motor power	.008	.199	.237	.504	-.017
CarChar2_ExDesign_R Exterior	.070	.153	.153	.495	-.063
CarChar9_EnvImp_R Environ impact	.038	-.024	.169	.068	.758
CarChar7_FuelConsum_R Fuel consumption	-.052	-.071	.258	-.030	.570
Diff3_HEFuel_R HV/EV	.323	.117	-.051	-.128	.357

Based on the literature review and factors identified in the exploratory factor analysis step, hypothetical relationships among predictors and factors were established. The hypothesized relations were then specified using confirmatory factor analysis. Figure 9 shows graphical output produced by IBM SPSS AMOS 22. Rectangular shapes indicate directly measured (i.e., observed/predictor) variables; ovals represent latent variables (i.e., factors). Each arrow indicates the direction of influence. The double-sided arrows indicate correlation between variables. A series of analyses were conducted to find out the best fit model. The evaluation indices are summarized in Table 7. The chi-squared statistic, $\chi^2(113, N = 500) = 295.357$, $p < 0.001$, was statistically significant. The normed fit index (NFI) was .867, lower than a desired threshold of .900, but respectable. The GFI and the CFI were .934 and .913. The RMSEA was 0.057 with a 90 percent confidence interval of 0.049 to 0.065. Together, the analysis shows an excellent fit of the data; all five factors from the exploratory factor analysis remained in the model.

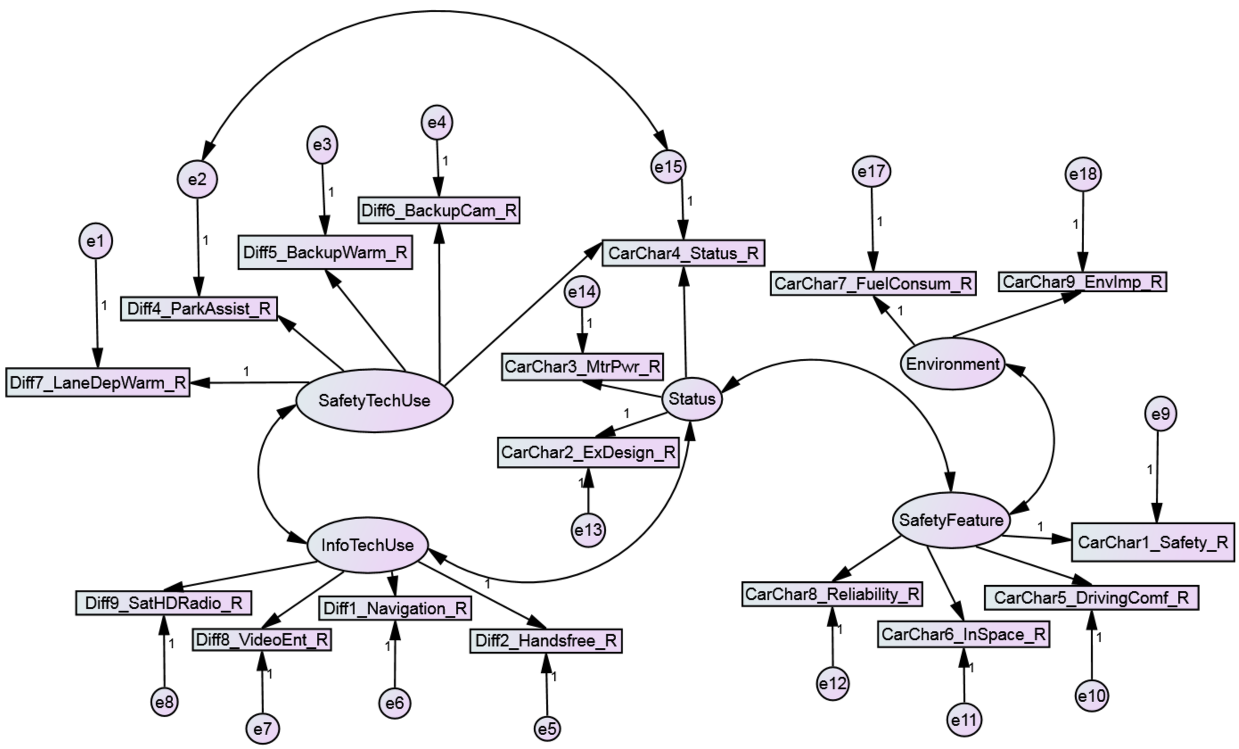


Figure 9. Graphical representation of the specified confirmatory factor analysis results from IBM SPSS AMOS 22.

Table 7. The Model Fit Indices: Confirmatory Factor Analysis

Fit Measures	Measurement Values
χ^2	$\chi^2(113, N = 500) = 295.357, p < .001$
NFI	.867
GFI	.934
CFI	.913
RMSEA	0.057

Socioeconomic variables (gender, age, income, education, and race) and estimated WTP were added to the confirmatory factor analysis output shown in Figure 9 to build an initial structural model, the second stage of the structural equation model. The tests in this stage identified five factors and socioeconomic variables associated with driver innovativeness that were measured earlier in the study. The relationships of these variables were found significant by *t*-tests and one-way ANOVA, as discussed earlier. After running the initial structural model, statistically insignificant variables and factors were removed from the model as suggested by Meyers et al. [72]. The re-specified model is graphically reproduced in Figure 10 for the sake of readability. Compared to the confirmatory factory analysis, only two factors and 11 predictor variables were left in the final model. The present structural model assessed the direct and indirect effects of latent predictors (factors in ovals) and predictor variables on drivers' WTP for CV technology. Each latent variable was measured with four indicator variables. The indicators of "SafetyTechUse," the use of safety-related in-vehicle technology, were represented by the current use of safety-related in-vehicle technologies such as parking assistance, back-up warning, back-up camera, and lane departure warning. Information and communication devices such as navigation, hands-free control, video entertainment, and satellite HD radio were indicators of "InfoComUse," the use of information and entertainment in-vehicle technology use. A full-information maximum likelihood procedure was employed in estimating the parameters. Five criteria were employed to assess the measurement model (Table 8). The chi-squared test was statistically significant, $\chi^2(52, N = 500) = 144.166, p < 0.001$. The NFI, comparing the fit over a null model, was .895, just below the desired threshold of 0.90. The other fit measures suggested an excellent model fit to the data. The GFI and the CFI were .952 and .929, respectively. The RMSEA was 0.060 with a 90 percent confidence interval of 0.048 to 0.071. All coefficients achieved statistical significance ($p < .05$). Most standardized regression coefficients were above practical significance (with values $\geq .30$). Finally, correlations between income and gender were significant at a 95 percent confidence level.

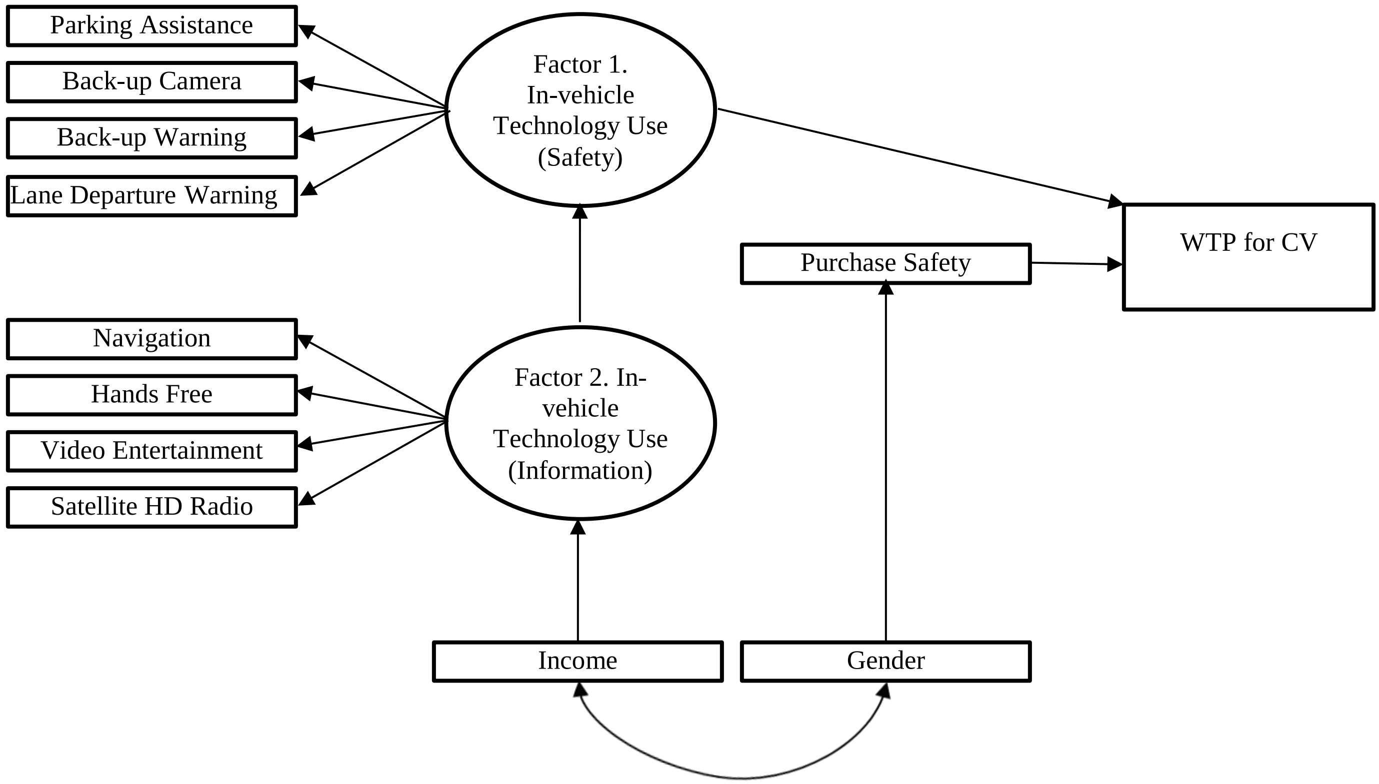


Figure 10. The specified model and its standardized coefficients.

Table 8. The Model Fit Indices: Structural Model

Fit Measures	Measurement Values
χ^2	$\chi^2(52, N = 500) = 144.166, p < .001$
NFI	.895
GFI	.952
CFI	.929
RMSEA	0.06

The structural equation model has excellent goodness-of-fit results, and warrants further discussion of the details. The specified model consists of the two structural equations (i.e., sub-models). First, it was predicted that the use of safety-related, in-vehicle technology in the current vehicle directly influences WTP, and the use of information and entertainment in-vehicle technology indirectly determines WTP through the safety equipment variable. In addition, income was predicted to play a moderating role. In other words, income was predicted to be a factor in buying a vehicle with various options of in-vehicle technology. Confirming past studies, the results of the SEM determined that the use of current technology influences driver's WTP. Correlations among two factor loadings, income and WTP, were statistically significant at a 95 percent confidence level. The first structure model implies that prior knowledge and use of in-vehicle technology positively influences WTP, that is, the adoption of CV. Also, through income's indirect influence, it can be inferred that early adopters of CV have higher incomes and are familiar with the latest in-vehicle technologies. The second structure shows the direct relationship between a purchasing decision variable, safety, and WTP and a moderating role of gender. This finding is especially interesting and also testifies to the robustness of the model.

A one-way ANOVA showed a significant influence of safety features on WTP and the association between gender and WTP was not significant. This is because ANOVA only shows a partial relationship assuming all other factors are constant. In SEM, variables' roles in relation to other direct and indirect measures are revealed. As a result, our model found that gender moderates WTP for those who are conscious of safety features. According to past studies [10, 11, 29] females have concerns about vehicle safety. These concerns imply that the safety benefits of CV would be a critical selling point to women.

Word Clouds for Open-Ended Questions

The research team used Wordle's Word Clouds interface to visualize the open-ended questions provided at the end of the survey. Word Clouds is built on a randomized greedy algorithm, one of the space-filling visualization methods [75, 76]. The randomized greedy algorithm packs words one by one for an efficient use of space leading to a final layout [76]. Frequently appearing words are represented in thicker and larger fonts, making them visually clear and easily identifiable. Figures 11–13 show the word cloud images created for each open-ended question: (1) benefits, (2) constraints/concerns, and (3) comments. For the answers related to the benefits of CV, "safety" was the most common word (Figure 11). "Accident" and "driving" were also notable. This shows participants expected CV technologies to allow them to drive more safely. "Cost" and "technology" were the most common words for the constraints/concerns (Figure 12). This is in line with the study finding stated earlier. Participants' acceptance of CV technologies, especially safety features, was high. However, as Figure 7 illustrated, pricing of new technology will be a barrier for a faster diffusion. Figure 13 shows high frequency words for the comments question. Many words are highly visible, but the most noticeable are "survey" and "none." This is likely due to a high frequency of the phrase "no comment" when participants had no specific input and mentioning "survey" while entering comments. Figures for different levels of CV knowledge are available in Appendix H.

Figure 11. Word cloud for “Benefits” (aggregated).

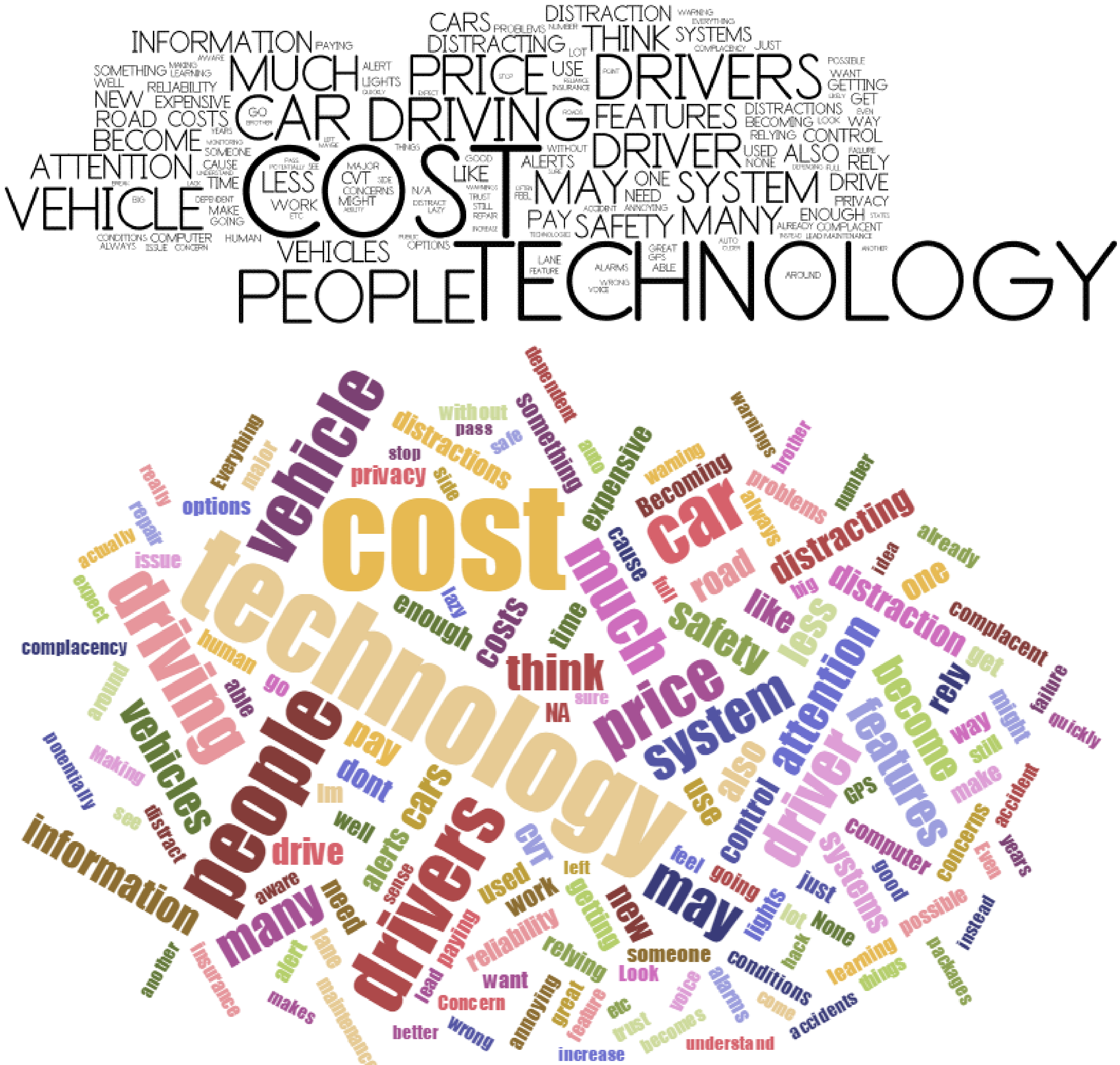


Figure 12. Word cloud for "Constraints/Concerns" (aggregated).

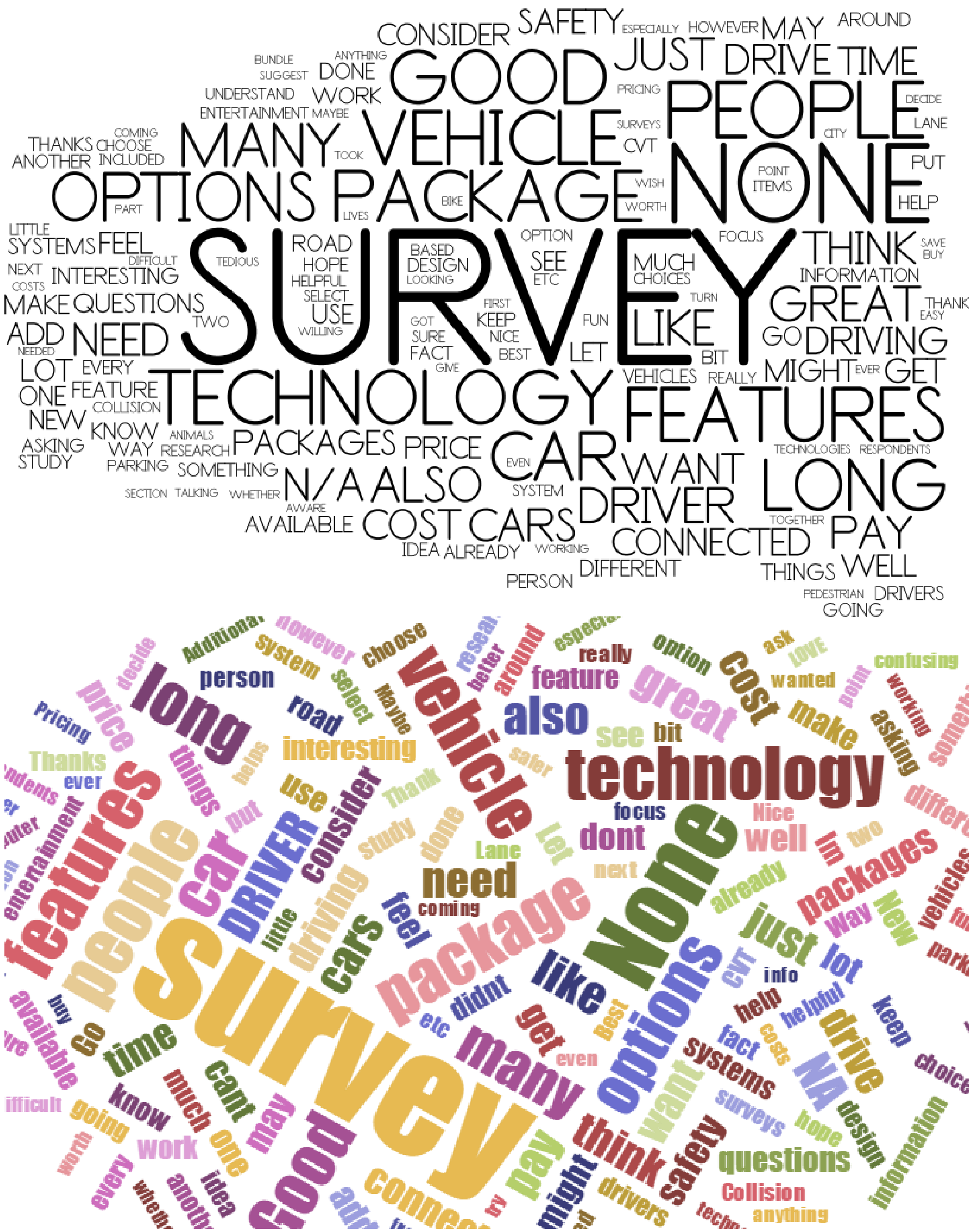


Figure 13. Word cloud for "Comments" (aggregated).

Conclusions: Discussion and Recommendations

The ACBC analysis was conducted to examine driver's preferences and WTP for CV technologies. The literature review found that demographic characteristics (e.g., gender, education, income, etc.), individual innovativeness, and knowledge of technology contribute to preferences and WTP. This study was mostly supportive of these findings.

Participants generally accepted the listed CV technologies. Compared to other values in each attribute, the average utilities for "None" were very low, implying that survey respondents would desire some CV technologies instead of choosing "None." As for gender difference, all else being equal, the preference structures of men and women were similar, suggesting other interacting variables (e.g., education, income) affecting gender difference. This similarity may be explained by the fact that women weigh safety features as a very important variable when evaluating different choices.

The comparison of the average importance of each attribute indicates that price would be the main factor in purchasing decisions. Of CV technology attributes, "Collision Package" had the highest importance score, confirming past studies regarding the decision variables of vehicle purchasing.

The WTP estimated by the ACBC analysis method illustrates that the amount consumers are willing to pay after negotiating pricing and attribute bundles is different from the amount derived from direct question-based methods. The BYO prices from the initial direct question to obtain participants' WTP were different from the WTP estimated by the ACBC analysis method with statistical significance. The decrease of WTP by 6 percent from the BYO price may imply that the ACBC survey reflects real purchasing behavior, in which participants make decisions by contemplating trade-offs of alternatives, reasonably well. The comparisons of WTP with several socioeconomic variables found that drivers between 40 and 49 years old, African-Americans, those with less than a bachelor's degree, and those with a higher budget for vehicle purchase are positively related to WTP. Confirming the findings of the literature review, the level of CV knowledge and innovativeness (i.e., early adopters) are highly associated with WTP.

The assessment of interactions among variables revealed an interesting picture that provides important policy implications for a faster CV deployment. A structural equation model was constructed to answer an important question: Who would choose CV, and what are the characteristics of early adopters? An exploratory factor analysis, confirmatory factor analysis, and SEM were conducted in order to answer these questions. A series of statistical analyses were intended to reveal unobserved or hard-to-observe relationships among personal characteristics, innovativeness indirectly measured by the current use and ownership of in-vehicle technology, and vehicle purchasing decision-making variables. A literature review and exploratory factor analysis provided theoretical background on personal traits of product adoption. Both a confirmatory factor analysis and structural equations found two statistically significant fitted models, identifying the characteristics of early adopters. The first structure model suggests that high-income individuals using recent in-vehicle safety, information, and entertainment technologies should be targeted at the earliest stage of CV deployment. The second structure model implies that drivers, especially females, who highly value vehicle safety are willing to pay more for CVs. These findings provide broader policy directions to facilitate faster diffusion of CVs.

Policy Suggestions

This study provides guidance for what a CV deployment plan should address. Price would be one of the most important determinants. While prices would decrease over time, a pricing policy to assist low-income people would help materialize the full benefits of CV technologies quickly. Also, effective CV education and outreach programs targeting those with low WTP (e.g., drivers 50 and older) need to be considered. As found in the current study, the level of knowledge about CV technologies is a strong indicator of WTP. The Collision Package received the greatest acceptance, followed by the Travel Assistance Package. If the technology is gradually deployed, the Collision and Travel Assistance packages should be priorities.

Our findings suggest that an appropriate way for segmenting the market is by gender, and that to facilitate a faster diffusion of this new technology the target audience should be women. In essence, women would be more interested in adopting the new safety innovations in vehicles provided by CV technology, but are less informed about this technology when compared to men. Those women who claim to be informed seem willing to pay more for CV technology than those women who claim no previous knowledge about the technology. Given that a vast majority of women consider safety to be an important factor in the purchase decision, it could be argued that raising consumer knowledge about CV safety technology through media catering to women 50 and older and at family-oriented public events should be a priority. It is particularly important that compared to other vehicle technology and equipment, such as air bags and seat belts, which protect drivers and passengers no matter the availability of that equipment in other cars, the safety benefits of CV will be commensurate with the CV adoption rate. Therefore, targeting a particular population segment should be a critical diffusion strategy.

Future Research

The next step using the collected data is to conduct market simulation based on various diffusion scenarios. This will predict the time to be taken for a (near) full deployment of CV technologies. Scenario-based market simulation should provide important implications for practitioners. For example, long-term regional transportation plans at the metropolitan planning organization level should reflect the traffic impacts that the deployment of CV technology would bring. Reduction in crashes may decrease non-recurring disruption, meaning shorter travel times at faster speeds. In addition, various safety devices (e.g., collision prevention) would assure shorter headways between cars. These potential impacts should be factored into long-term transportation plans to make more informed decisions.

In addition, further analyses need to be conducted as follow-up studies. More interactions effects among variables should be further examined, and a potential multiplicity issue in repeated paired analysis needs to be studied comparing alternative methods for multiplicity adjustment.

Limitations

There are several limitations to the current study. First, since the sampling population was non-random and the survey was distributed online, there must be some degree of caution when interpreting the results. These findings are by no means representative of a regional or national market; instead, the study has tested gender and knowledge effects on WTP based on a convenience sample. Furthermore, the study included a subset of potential CV technology safety features, and as such did not represent all CV safety technology that is currently being explored or will be developed in the future. Finally, the study included estimates of potential pricing points for each new technological feature. These estimates were derived from current “smart” car safety technologies that exist in the marketplace (it should be noted that CV technology differs markedly from “smart” car technology, although driver benefits may be similar). It is unclear whether CV safety technologies, once launched into the marketplace, will adopt similar pricing points. Our results may vary depending on different pricing points for the various technologies, since price has a significant impact on WTP.

Appendix A. Acronyms, Abbreviations, and Symbols

Acronyms, Abbreviations, and Symbols	Expansion and Explanation
3G	3rd Generation of wireless technology
AASHTO	American Association of State Highway and Transportation Officials
ACA	adaptive conjoint analysis
ACBC	adaptive choice-based conjoint
ANOVA	analysis of variance
BCA	benefit-coast analysis
BYO	Build Your Own (Sawtooth Software)
CA	conjoint analysis
CAR	Center for Automotive Research
CBCA	choice-based conjoint analysis
CFI	comparative fit index
CV	connected vehicle
CVI	connected vehicle infrastructure
CVI-UTC	Connected Vehicle/Infrastructure University Transportation Center
DAC	Driver Acceptance Clinic
DNPW	Do Not Pass Warning
DSRC	dedicated short-range communications
EEBL	Emergency Electronic Brake Light
FCW	Front/Forward Collision Warning

Acronyms, Abbreviations, and Symbols	Expansion and Explanation
GFI	goodness-of-fit index
GOF	goodness-of-fit
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronics Engineers
IMA	Intersection Movement Assist
ITS	Intelligent Transportation Systems
ITS JPO	ITS Joint Program Office
IV	intelligent vehicle
LTA	Left Turn Assist
MSU	Morgan State University
NFI	normed fit index
NHTSA	National Highway Traffic Safety Administration
OBE	onboard equipment
PCA	Pedestrian & Cyclist Alert
PSL	Parking Spot Locator
RCN	Road Condition Notification
RITA	Research and Innovative Technology Administration
RMSEA	root mean squared error of approximation
RP	revealed preference
SCW	Side Collision Warning
SEM	structural equation modeling

Acronyms, Abbreviations, and Symbols	**Expansion and Explanation**
SP	stated preference
TAM	Technology Acceptance Model
UA	user acceptance
U.S. DOT	United States Department of Transportation
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
VCTIR	Virginia Center for Transportation Innovation and Research
VII	Vehicle Infrastructure Integration
VTTI	Virginia Tech Transportation Institute
WTP	willingness-to-pay/purchase
X	In SEM: A measured variable (exogenous)
Y	In SEM: A measured variable (endogenous) in SEM
β (“beta”)	In SEM: A path representing a causal relationship (regression coefficient) from one η construct to another η construct
Β (“beta”)	In SEM: A way of referring to the entire set of β relationships for a given model
γ (“gamma”)	In SEM: A path representing a causal relationship (regression coefficient) from a ξ to an η
Γ (“gamma”)	In SEM: A way of referring to the entire set of γ relationships for a given model
δ (“delta”)	In SEM: The error term associated with an estimated, measured Y variable
ε (“epsilon”)	In SEM: The error term associated with an estimated, measured X variable

Acronyms, Abbreviations, and Symbols	**Expansion and Explanation**
ζ (“zeta”)	In SEM: A way of capturing the covariation between η constructs errors
η (“eta”)	In SEM: A construct associated with measured Y variables (endogenous)
Λ (“lambda”)	In SEM: A way of referring to a set of loading estimates represented in a matrix where rows represent measured variables (either X or Y) and columns represent latent constructs (either ξ or η)
ξ (“ksi”)	In SEM: A construct associated with measured **X** variables (exogenous)
φ (“phi”)	In SEM: A correlational relation between exogenous constructs

Appendix B. Selected CV Attributes and Features

The research team tried employing various arrangements of CV applications based on attributes, features, and levels in the ACBC analysis. After identifying possible applications for motor vehicles (especially passenger vehicles), the research team initially categorized them based on benefits (including safety alerts, control and vision aids, active controls, convenience, commercial appeal, etc.). Later, realistic cost estimation prompted the team to redo the previous categories, and new categories were applied based on the devices that could provide various benefits. However, this device-based categorization was deemed somewhat complicated for non-technical people who might participate in the project. At last, the team decided to use a benefit-based format for attributes improved by a modified cost structure (see Appendix C). Some CV applications that are currently not intuitive enough were modified or removed from the survey. The team also wanted to optimize the number of attributes and features, based on suggested values, to implement ACBC for the purpose of limiting the survey's level of complexity. Shin et al. [11] employed a fractional factorial design maintaining orthogonality among attributes. The purpose was to decrease the number of combinations of CV equipment bundles. As a result, the number of choices for vehicle and smart options dropped from 576 to 24, and from 96 to 16, respectively. The suggested range for number of attributes in ACBC is 5 to 12, and the maximum number of levels should not exceed 35 [59]. The final numbers for attributes, features, and levels used in this project were 5, 11, and 21, respectively.

Table 9 shows selected attributes, features, and levels considered in this project.

Table 9. List of Selected CV Attributes, Features, and Levels

Attributes	Features	Levels
Collision Package	Front Collision Warning	N/A
	Side Collision Warning	Front Collision Warning
	All-Around Collision Warning	Side Collision Warning
		Front & Side Collision Warning
		All-Around Collision Warning
Driver Assistance Package	Lane Departure System	N/A
		Lane Departure System
	Intersection & Left Turn Assist	Intersection & Left Turn Assist
		Lane Departure System and Intersection & Left Turn Assist
Enhanced Safety Package	Do Not Pass Warning	N/A
		Do Not Pass Warning
	Pedestrian & Cyclist Alert	Pedestrian & Cyclist Alert
		Do Not Pass Warning and Pedestrian & Cyclist Alert
Road Information Package	Road Condition Notification	N/A
		Road Condition Notification
	Slow/Stop/Wrong-Way Vehicle Advisor	Slow/Stop/Wrong-Way Vehicle Advisor
		Road Condition Notification and Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	Real time Travel Planning & Route Optimization	N/A
		Real time Travel Planning & Route Optimization
	Parking Spot Locator	Parking Spot Locator
		Real time Travel Planning & Route Optimization and Parking Spot Locator

For the purpose of consistency with previous studies, the research team included (directly or indirectly) all of the features that had been tested in Driver Acceptance Clinics (DACs) (Table 10).

Table 10. Corresponding Features of DAC Studies in Current Project

Driver Acceptance Clinics Features	Corresponding Feature in Current Project
Emergency Electronic Brake Light (EEBL)	Slow/Stop/Wrong-Way Vehicle Advisor
Forward Collision Warning (FCW)	Front Collision Warning
Blind Spot Warning/Lane Change Warning (BSW/LCW)	Side Collision Warning
Left Turn Assist (LTA)	Intersection & Left Turn Assist
Intersection Movement Assist (IMA)	
Do Not Pass Warning (DNPW)	Do Not Pass Warning

Appendix C. Price Estimation for Selected CV Attributes & Features

Currently, CV technologies are not available in the market and, therefore, market prices are not available. Depending on market penetration and actual market acceptance, which is subject to a multifactorial structure, their actual market prices will be determined over time. However, several different studies were analyzed and investigated to determine the factors affecting CV prices and estimate some potential prices.

- An important determinant of the public perception of ITS applications is the cost associated with implementation [77].

- "While a connected vehicle system may be costly to implement, if the public perceives the benefits as being worth the costs, there may still be widespread support for the system. Public costs will stem from the specialized methods, personnel, and equipment required in deploying, operating, and maintaining a connected vehicle system. The system may require purchasing new equipment and hiring new personnel with specialized skills or allocating resources to train current employees. Initial deployment costs and training requirements could be significant and may require a major upgrade and overhaul of existing databases and security infrastructure. Costs to the public will be both direct (price premium on vehicles equipped with connected vehicle technology or price of aftermarket equipment) and indirect (taxes or fees to pay for deployment of infrastructure needed for the connected vehicle system). To convince drivers to use connected vehicle technology in their personal vehicles, they will have to perceive the cost of the technology as less than the benefits they accrue through the use of connected vehicle applications. Beyond getting drivers to adopt the technology in their vehicles, acceptance is needed from the broader public, which through taxes and fees will be funding much of the costs associated with infrastructure deployment. If the proposed connected vehicle system is seen as a waste of public funds, it may be politically difficult to move forward on implementation. To gain broader public acceptance from taxpayers, a connected vehicle system will need to be accessible to a broad range of drivers who perceive benefits from the system and it may need to offer value even to those who do not purchase in-vehicle technology [78]."

- "However, there is not such a detailed study about addressing associated CV aftermarket prices. An initial estimate from the VII program was that the basic GPS and DSRC radio components should be available for "well under $50" per vehicle, and a figure of $50 per vehicle was used in the March 2007 BCA report. Some comments received on the March 2007 BCA Report suggested that this estimate may be too low; however, the Task Force raised no concerns that this value was outside of a reasonable range. The $50 per vehicle figure is again used here, but with a sensitivity test showing the effects of alternative values. As in the 2007 BCA, it is assumed that each year, 2 percent of OBE units will require repair or replacement due to electronics failure, software problems, or vehicle damage. The Task Force was unable to provide additional input on this assumption due to antitrust concerns, but overall it was viewed as reasonable given the experience of other onboard electronics. Because it is likely that repair or replacement of OBE will be more expensive than the initial factory installation (due to the absence of economies of scale), the BCA assumes that the repair cost is $100 per unit rather than $50 [79]."

- "Adding connected vehicle technology will inevitably add costs to the vehicle. Private-sector respondents were asked how much various degrees of implementation would add to the base price of a vehicle, as well as including equipment as aftermarket. In both rounds, when asked how much it will cost vehicle manufacturers (in US$) to add a DSRC radio as embedded equipment, respondents gave a median response of $175 for 2017 and $75 for 2022. Regarding what connected vehicle technology will add to the base cost (in US$) of a new vehicle for the consumer, the median in both rounds was $350 for 2017 and $300 for 2022. As for the cost for the consumer (in US$) to add DSRC as aftermarket equipment, the median for both rounds was $200 for 2017 and $75 for 2022 [78]."

- In another study, a WTP analysis of CV was made based on the question, "How much extra would you be willing to pay to have this technology on a vehicle you drive?" There was not any kind of marketing method to examine the respondents' WTP. In the U.S., 25 percent of respondents (75th percentile) were willing to pay at least $500 for this technology. The corresponding amounts in the Australia and the U.K. were $455 and $394, respectively. However, a sizeable proportion of respondents said they would not be willing to pay extra for this technology (a response of $0 was given by 45.5 percent in the U.S., 44.8 percent in the U.K., and 42.6 percent in Australia) [14].

There are no clear guidelines or estimates about the cost of CV applications to users. There were some efforts to estimate dedicated short-range communications (DSRC) prices or the amount people were willing to pay for the technology, but there were not enough details about additional required or desirable devices, such as the environment in which drivers will be notified (screen, sound, etc.), inter-vehicle connections, wiring, security, etc. Moreover, it is not yet clear who will be in charge of infrastructure and ongoing research.

Studies like the current project are among those that aim to answer these kinds of questions. In the literature of choice-based WTP studies (especially ACBC), price-level estimates have mainly been done based on a precise modification of existing or similar products. Toubia et al. [56] chose four price levels for their wine experiment based on pretests; however, their study was largely a methodological study, and the chosen amount of price estimation precision was sufficient for methodological comparison and especially for study of the impact of consumer preferences. Abernethy, Evgeniou, Toubia, and Vert [66] used four price levels for their digital camera experiment ($500, $400, $300, and $200). Eggers and Sattler [80] used European flights as their empirical experiment to validate their proposed new method of choice-based WTP with actual flight prices between different major European cities with different price levels (two, three, and six). Jervis, Ennis, and Drake [81] used six price levels similar to real-world prices and applied a series of prohibitions in the survey to prevent unrealistic combinations of price and container size for their sour cream experiment. Gensler, Hinz, Skiera, and Theyson [82] examined WTP for two field studies. For membership in a supporter club in Germany, they investigated the fees charged by supporter clubs in other countries to select the appropriate price levels. For a digital video recorder, they searched for relevant attributes and attribute levels among potential buyers, reviewed current offers, and interviewed potential buyers to determine price levels. Hackbarth and Madlener [83] conducted a stated choice study for alternative fuel vehicle characteristics for Germany, and the vehicle purchase price variable was adjusted to respondents' stated price range of their latest or next vehicle purchase (as a reference value), respectively, and varied around this value by ±25 percent (i.e., 75 percent, 100 percent, and 125 percent). In a recent study on WTP for electric vehicles, Daziano and Chiew [84] designed the experimental levels in a way that reflected a realistic situation compared to current market attributes.

As with these studies, the research team extensively reviewed currently available technologies like those used for CVs. Initially, the basic car price was also included in the price estimation structure, but the team ultimately decided to focus on and include only CV attributes and feature prices. However, minimum and maximum values of the next vehicle to be purchased were added to the online survey prior to the BYO section (i.e., separate questions with multiple choices).

The main purpose of this research was to identify WTP and user acceptance (UA). To achieve those using Sawtooth Software's capabilities, the study team used the following stages to address CV prices.

- **Stage 1** – Initial prices (presented during the BYO section to survey participants) were almost similar to current intelligent vehicle (IV) market prices. Table 11 summarizes the current (2013) IV packages market. Table 12 shows estimated prices for selected CV attributes and features from the BYO section of survey.
- **Stage 2** – Sawtooth Software's capability of modifying prices (±30 percent) during ACBC screening choice questions was used to analyze participants' WTP and UA. Table 13 shows the price ranges that respondents possibly could see during the completion of the online survey. This adjustment resembled the variations in the actual WTP of participants and was done based on Sawtooth Software recommendations. It allowed the utility of non-price attributes to be interpreted independently from those associated with price increments [59].

Table 11. 2013 IV Packages Market Prices

Brand	Package (and Price [$])
Audi	Driver Assist Package (including adaptive cruise control, distance setting, speed, enhanced braking guard, etc.) = $3,000
BMW	Driver Assistance Package (including speed, driving assist, lane departure, etc.) = $1,900 Navigation System (including remote services, real time traffic, BMW apps, smartphone integration, etc.) = $2,150 Park Distance Control (front & rear sensors) = $750 Technology Package (including voice command, real-time traffic, navigation, etc.) = $2,350; $2,800
Cadillac	Driver Assist Package (including driver awareness package, adaptive cruise control, automatic collision prevention, electronic parking brake, etc.) = $3,220; $3,645
Chevrolet	Convenience Package (including rear park assist, rear vision camera, etc.) = $940 Advanced Safety Package (including forward collision warning, rear cross traffic, lane departure, etc.) = $890 Navigation Package (including radio with navigation, keyless access, etc.) = $1,095
Lexus	Navigation System = $3,225 Blind Spot Monitor = $600 Back Up Monitor = $350 Parking Assist (front & rear sensors) = $500
Mercedes-Benz	Lane Tracking Package (blind spot and lane keeping) = $850 Driver Assistance Package (including active blind spot and active lane keeping) = $2,950 Parking Assist Package = $1,290 Night View = $1,780
Porsche	Rear Park Assist = $530 Rear and Front Park Assist = $860 Lane Change Assist = $850 and Lane Departure Warning = $630 Adaptive Cruise Control (including distance control, etc.) = $2,170; $2,690
Toyota	Blind Spot Monitor = $500
Volvo	Technology Package (including adaptive cruise control, collision warning, distance alert, etc.) = $1,500 Blind Spot Package (including front and rear park assist, lane change and merge aid, etc.) = $900

Source: USAA Buying Car Website and other leading auto manufacturers' websites (2013)

Table 12. CV Price Estimates (at BYO)

Attribute	Feature	Price ($)
Collision Package	Nothing	0
	Front Collision Warning	350
	Side Collision Warning	600
	Front & Side Collision Warning	900
	All-Around Collision Warning	1,100
Driver Assistance Package	Nothing	0
	Lane Departure System	600
	Intersection & Left Turn Assist	750
	Lane Departure System and Intersection & Left Turn Assist	1,200
Enhanced Safety Package	Nothing	0
	Do Not Pass Warning	300
	Pedestrian & Cyclist Alert	750
	Pedestrian & Cyclist Alert and Do Not Pass Warning	1,000
Roadway Information Package	Nothing	0
	Road Condition Notification	300
	Slow/Stop/Wrong-Way Vehicle Advisor	300
	Road Condition Notification and Slow/Stop/Wrong-Way Vehicle Advisor	500
Travel Assistance Package	Nothing	0
	Real Time Travel Planning & Route Optimization	250
	Parking Spot Locator	500
	Real Time Travel Planning & Route Optimization and Parking Spot Locator	700
All	**Highest Levels**	**4,500**

Table 13. CV Price Estimates (after BYO)

Attribute	Feature	BYO Price ($)	Min. Price ($)	Max. Price ($)
Collision Package	Nothing	0	0	0
	Front Collision Warning	350	245	455
	Side Collision Warning	600	420	780
	Front & Side Collision Warning	900	630	1,170
	All-Around Collision Warning	1,100	770	1,430
Driver Assistance Package	Nothing	0	0	0
	Lane Departure System	600	420	780
	Intersection & Left Turn Assist	750	525	975
	Lane Departure System and Intersection & Left Turn Assist	1,200	840	1,560
Enhanced Safety Package	Nothing	0	0	0
	Do Not Pass Warning	300	210	390
	Pedestrian & Cyclist Alert	750	525	975
	Pedestrian & Cyclist Alert and Do Not Pass Warning	1,000	700	1,300
Roadway Information Package	Nothing	0	0	0
	Road Condition Notification	300	210	390
	Slow/Stop/Wrong-Way Vehicle Advisor	300	210	390
	Road Condition Notification and Slow/Stop/Wrong-Way Vehicle Advisor	500	350	650
Travel Assistance Package	Nothing	0	0	0
	Real Time Travel Planning & Route Optimization	250	175	325
	Parking Spot Locator	500	350	650
	Real Time Travel Planning & Route Optimization and Parking Spot Locator	700	490	910
All	**Highest Levels**	**4,500**	**3,150**	**5,850**

Appendix D. Survey Flyer

Invitation to Online Survey on New Vehicle Technology

for Drivers over 18 years of age

You are invited to participate in a study "Measuring User Acceptance of and Willingness-to-pay for CVI Technology" sponsored by the U.S. Department of Transportation and conducted by a research team at Morgan State University. You must be at least 18 years old and have a valid driver's license.

The primary goal of this study is to identify drivers' preferences and willingness-to-pay on Connected Vehicle (CV) technologies. CVs have capability of real time communication with other CVs and infrastructure which are expected to bring safety and mobility benefits to road users.

This survey will collect information on drivers' preferences and acceptable prices of different on-board connected vehicle devices. The survey will take about 20 minutes to complete. Please use the following survey link to join the survey at your earliest convenience:

http://WTPSurvey1.cloudssi.com/login.html

Your participation in this study is completely voluntary, and there is no or minimal risk associated with participating in this survey. Your survey responses will be anonymous and confidential. You are free to discontinue the online survey at any time during your participation. In addition, if you would like, please redistribute this survey to your family, colleagues, and friends.

Should you have any questions, please contact Dr. Hyeonshic Shin (Principal Investigator) by phone (443-885-1041) or email (hyeonshic.shin@morgan.edu).

National Transportation Center

1700 E. Cold Spring Lane
Baltimore, MD 21251

Phone: 443-885-3666
Fax: 443-885-8275
E-mail: hyeonshic.shin@morgan.edu

CVI UTC

MORGAN STATE UNIVERSITY

Appendix E. Online Survey Snapshots

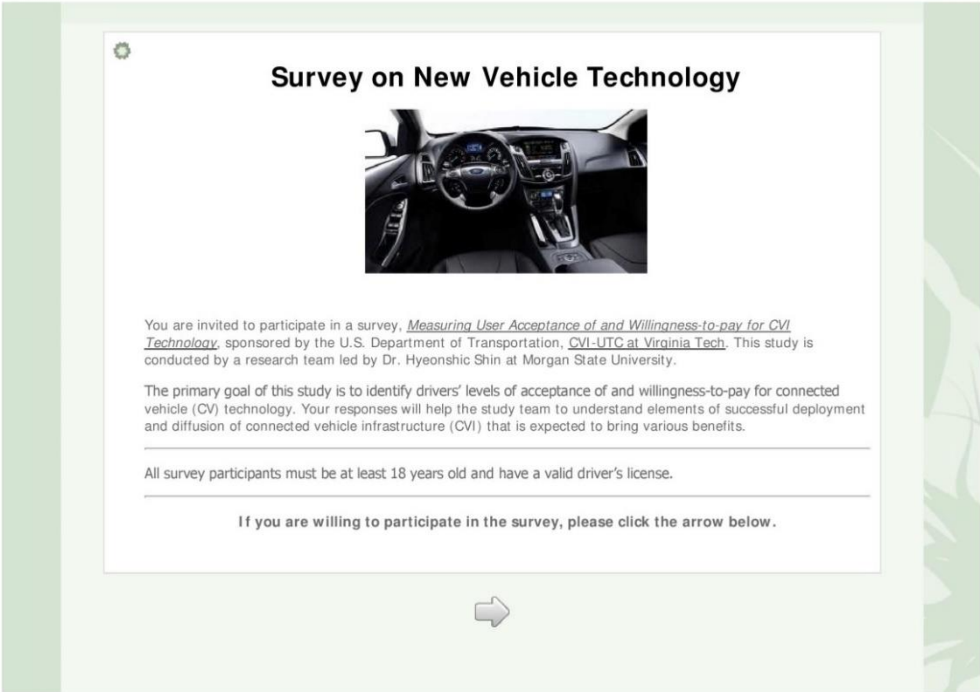
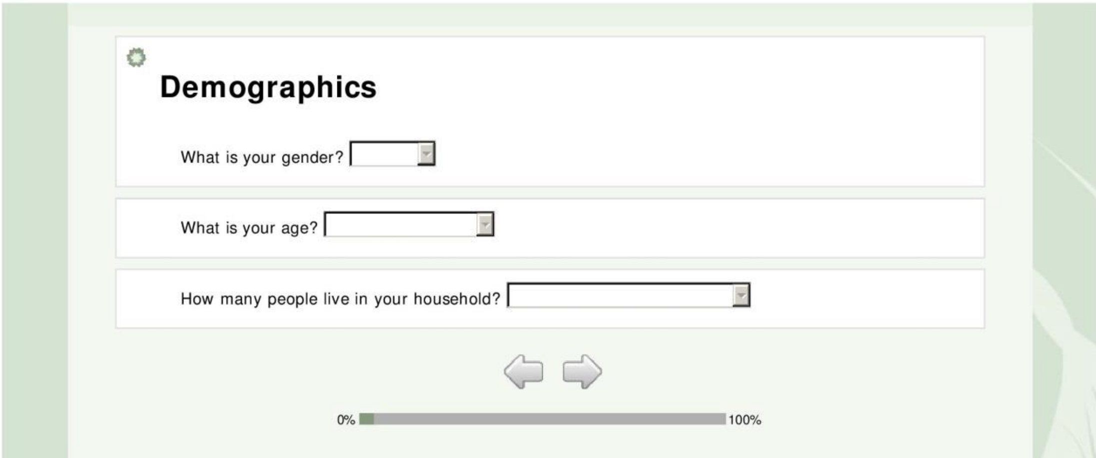
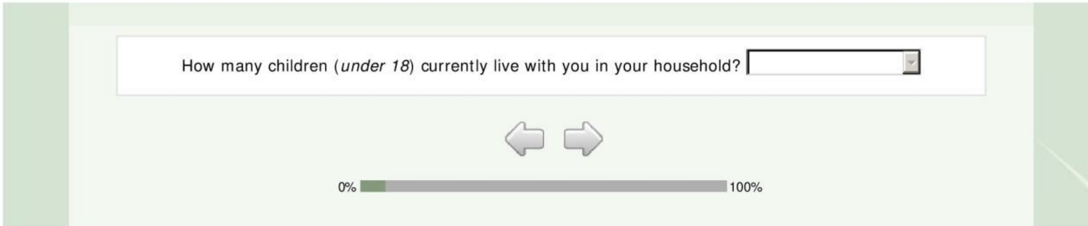
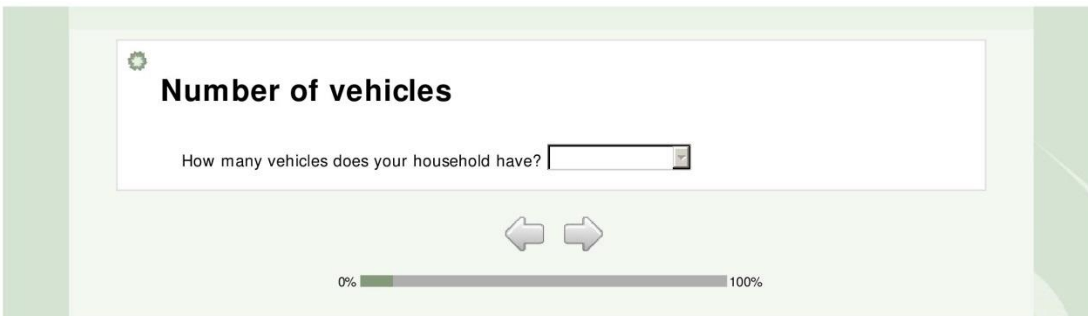
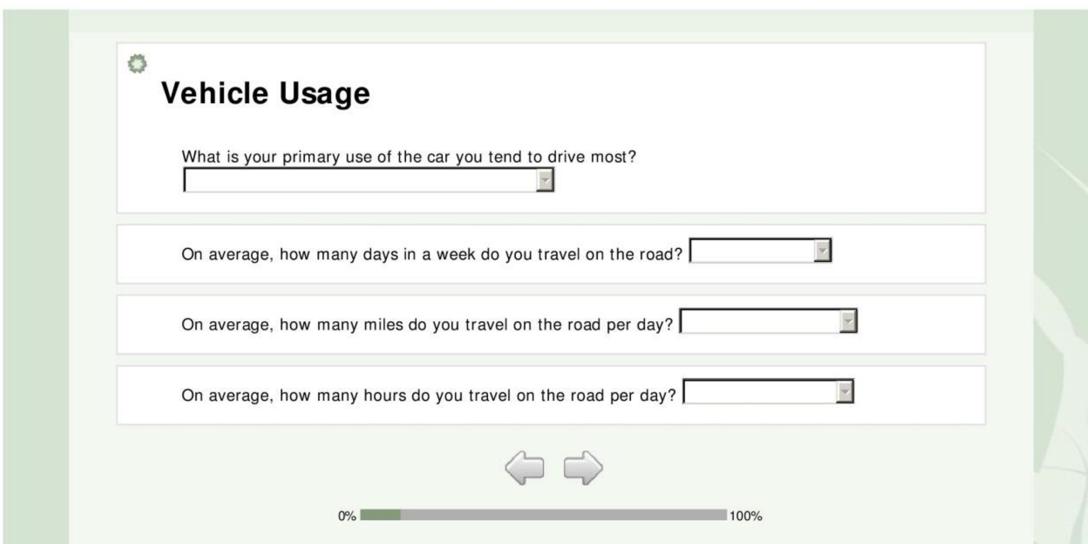


Image Source: [85]




How many children (*under 18*) currently live with you in your household?
0%
100%


Number of vehicles
How many vehicles does your household have?
0%
100%


Vehicle Usage
What is your primary use of the car you tend to drive most?
On average, how many days in a week do you travel on the road?
On average, how many miles do you travel on the road per day?
On average, how many hours do you travel on the road per day?
0%
100%

Please indicate whether you have any of the following technologies in your current car.

	Available in my current car	Not sure it's available in my current car	Not available in my car , but considering getting in my next car	Not available in my car, not planning on getting in my next car
Navigation System	○	○	○	○
Hands-free calling (e.g. Bluethooth)	○	○	○	○
Hybrid or electric fuel technology	○	○	○	○
Parking assistance technology	○	○	○	○
Back up warning system	○	○	○	○
Back up camera	○	○	○	○
Lane departure warning system	○	○	○	○
Video entertainment system	○	○	○	○
Satellite or HD radio	○	○	○	○

0% 100%

Your Current Vehicle

What kind of vehicle do you currently own/lease or use? *(If you have more than one vehicle, please refer to the vehicle that you drive the most).*

What type of engine does your current vehicle have?

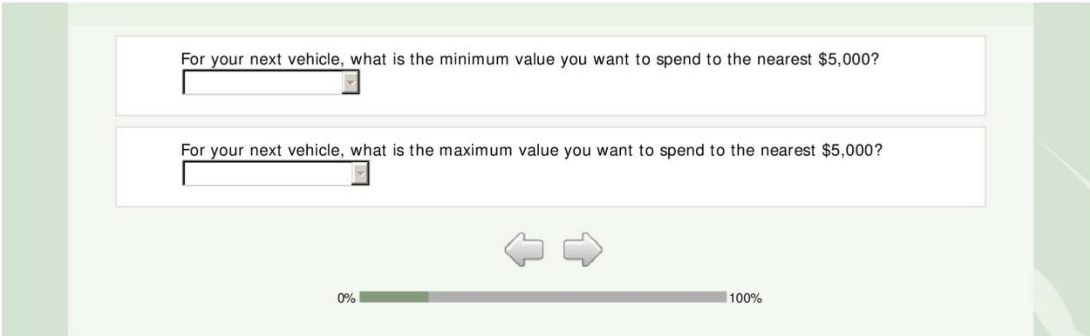
Your Next Vehicle

For your next vehicle, what type of vehicle are you likely to get?

What type of engine will your next car have?

For your next vehicle, what type of purchase/lease are you likely to do?

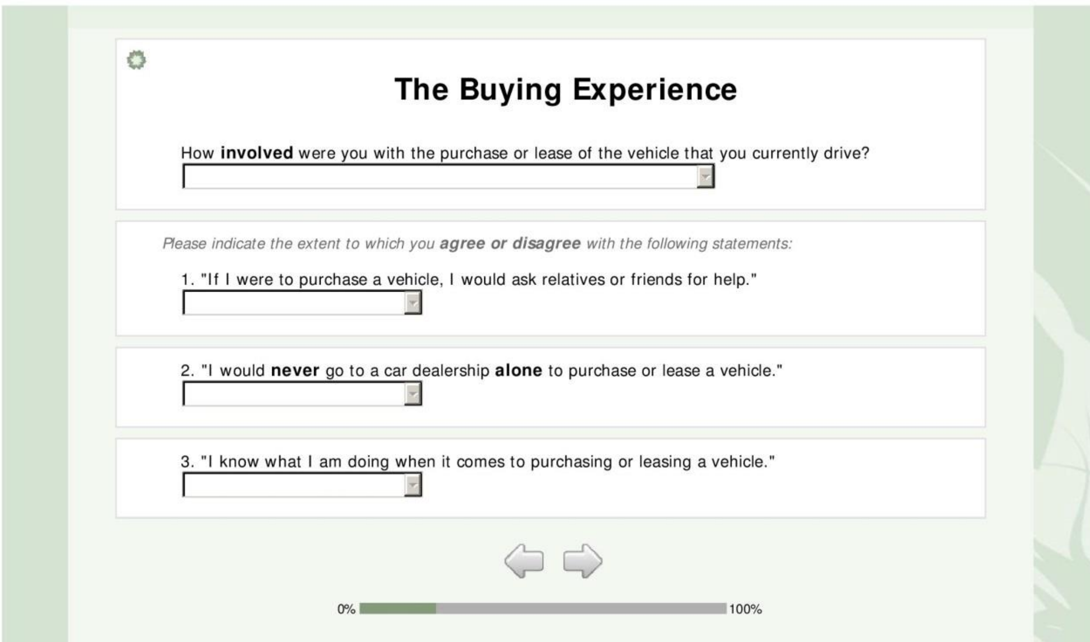
0% 100%



For your next vehicle, what is the minimum value you want to spend to the nearest $5,000?

For your next vehicle, what is the maximum value you want to spend to the nearest $5,000?

0% 100%



The Buying Experience

How **involved** were you with the purchase or lease of the vehicle that you currently drive?

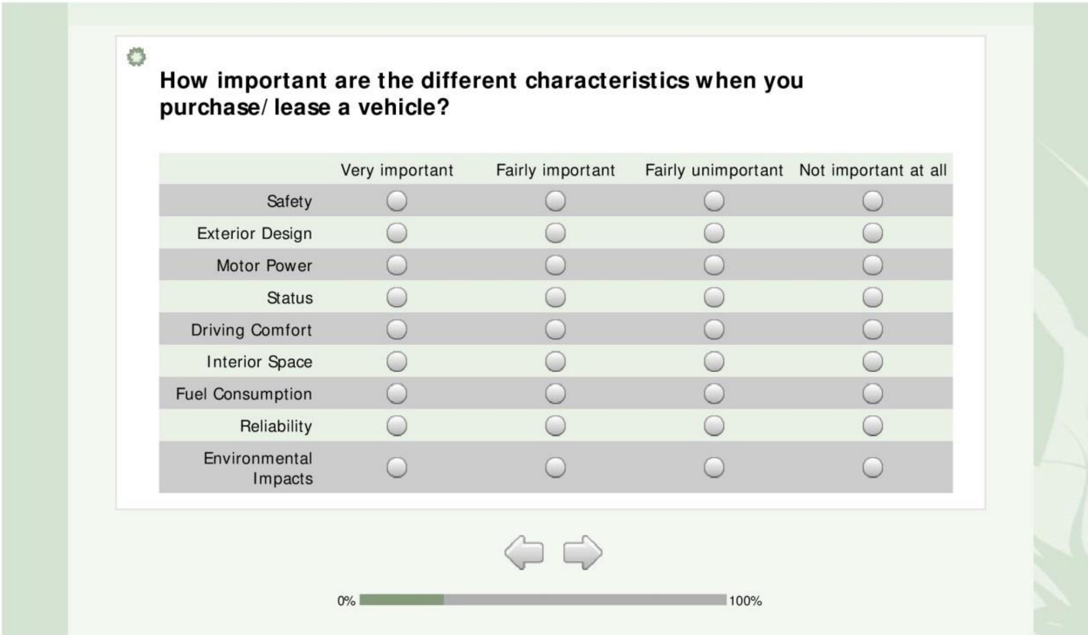
*Please indicate the extent to which you **agree or disagree** with the following statements:*

1. "If I were to purchase a vehicle, I would ask relatives or friends for help."

2. "I would **never** go to a car dealership **alone** to purchase or lease a vehicle."

3. "I know what I am doing when it comes to purchasing or leasing a vehicle."

0% 100%



How important are the different characteristics when you purchase/ lease a vehicle?

	Very important	Fairly important	Fairly unimportant	Not important at all
Safety				
Exterior Design				
Motor Power				
Status				
Driving Comfort				
Interior Space				
Fuel Consumption				
Reliability				
Environmental Impacts				

Image Source: [86]

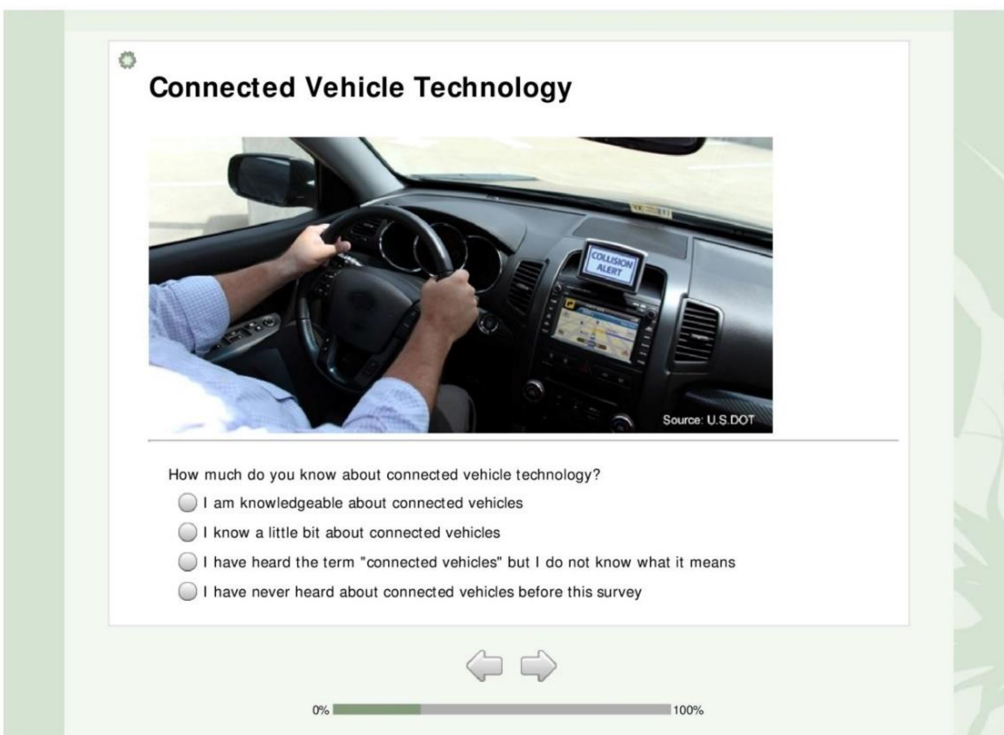


Image Source: [87]

Description of Connected Vehicle Technology

In order to enlarge the images on the right, please do not block script from running.

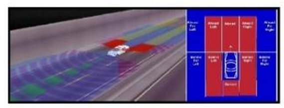
(1 of 3)

COLLISION PACKAGE

Front Collision Warning: An electronic system that enhances safety by monitoring the roadway in front of the vehicle and warning the driver when a potential collision risk exists.

Side Collision Warning: An electronic system that enhances safety by monitoring the lanes adjacent to the vehicle to detect moving and stationary objects within the side blind spots. The system provides warnings to drivers of possible collisions with vehicles traveling in an adjacent lane.

All-Around Collision Warning: An electronic system that enhances safety by monitoring the roadway in front, to the side, and behind the vehicle and warning the driver when a potential collision risk exists.



DRIVER ASSISTANCE PACKAGE

Lane Departure Warning System: An electronic system that monitors the position of the vehicle within a roadway lane and warns the driver, if the vehicle deviates or is about to deviate outside the lane.

Intersection & Left Turn Assist: An electronic system that assists drivers in making turns at intersections and left turns on roads. The intersection and left turn assistant will warn the driver when the system detects vehicles that may not be visible.

0% 100%

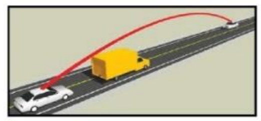
Image Sources: [88, 89, 90]

Description of Connected Vehicle Technology

(2 of 3)

ENHANCED SAFETY PACKAGE

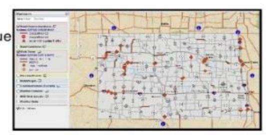
Do Not Pass Warning: An electronic system that warns the driver when a slower moving vehicle cannot be safely passed using a passing zone which is occupied by vehicles in the opposite direction of travel.



Pedestrian & Cyclist Alert: An electronic system that warns the driver about pedestrians or cyclists on the road.

ROADWAY INFORMATION PACKAGE

Road Condition Notification: An electronic system that informs the driver of potentially dangerous driving conditions due to a road feature or hazard (e.g., potential traction loss, poor visibility, fallen tree, debris on the road, construction work).



Slow/Stop/Wrong-Way Vehicle Advisor: An electronic system that warns the driver of a slowing or stopped vehicle that can be several cars ahead. The system also warns the driver if the vehicle turns into a lane going in the opposite direction.

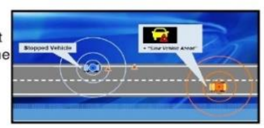


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Image Sources: [91, 92, 93, 94]

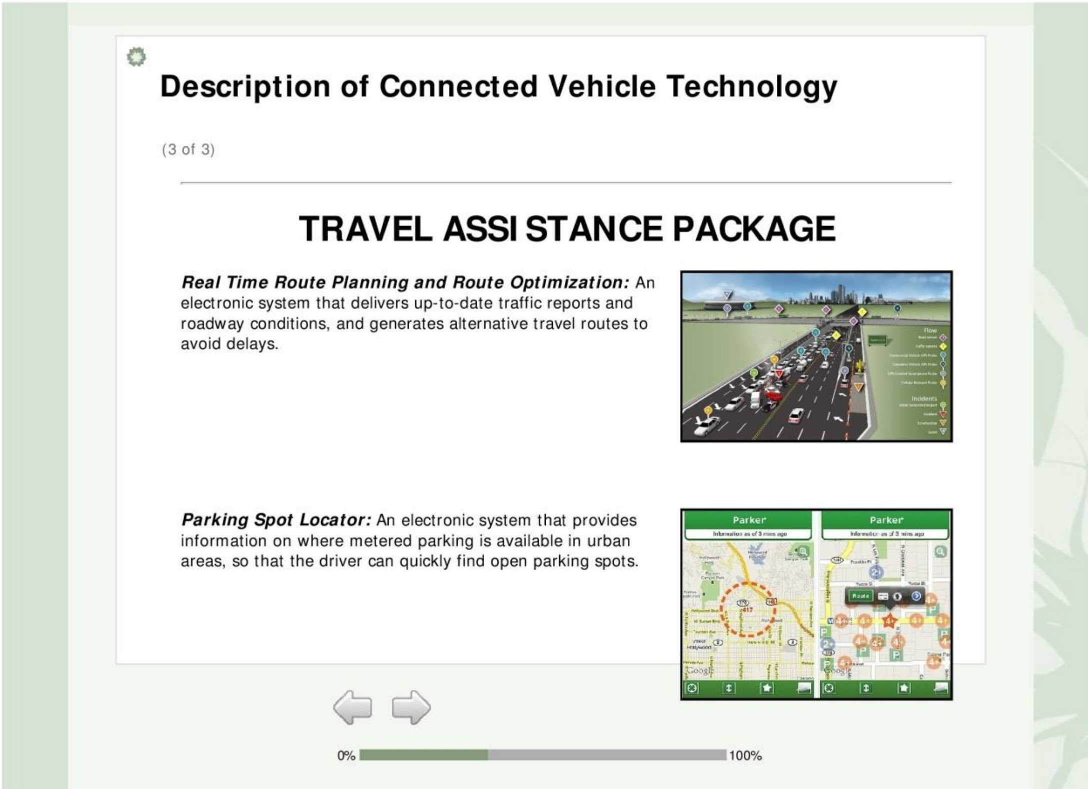
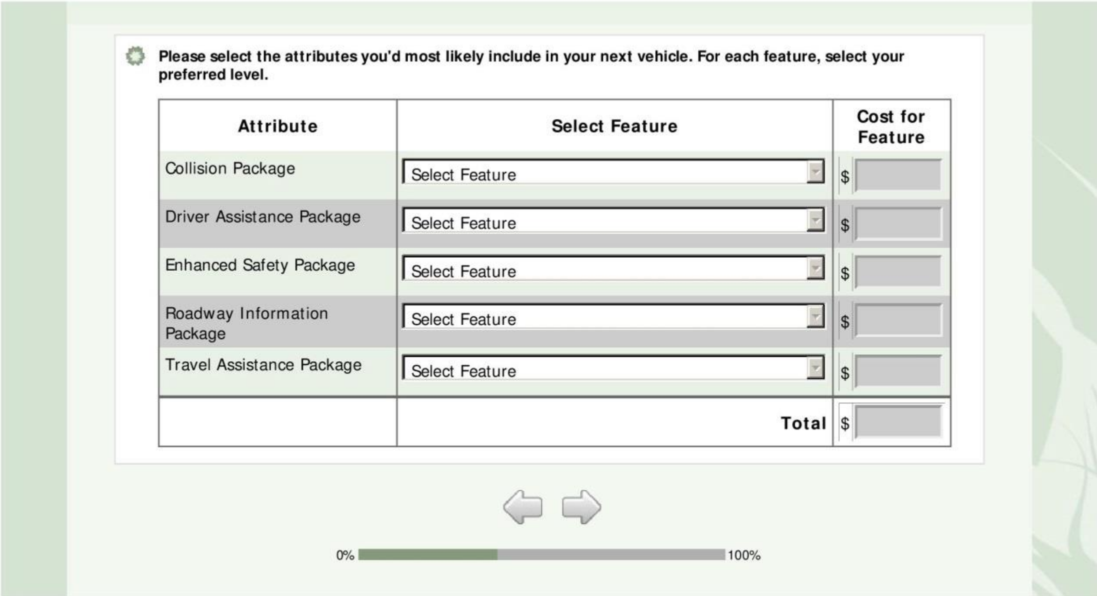


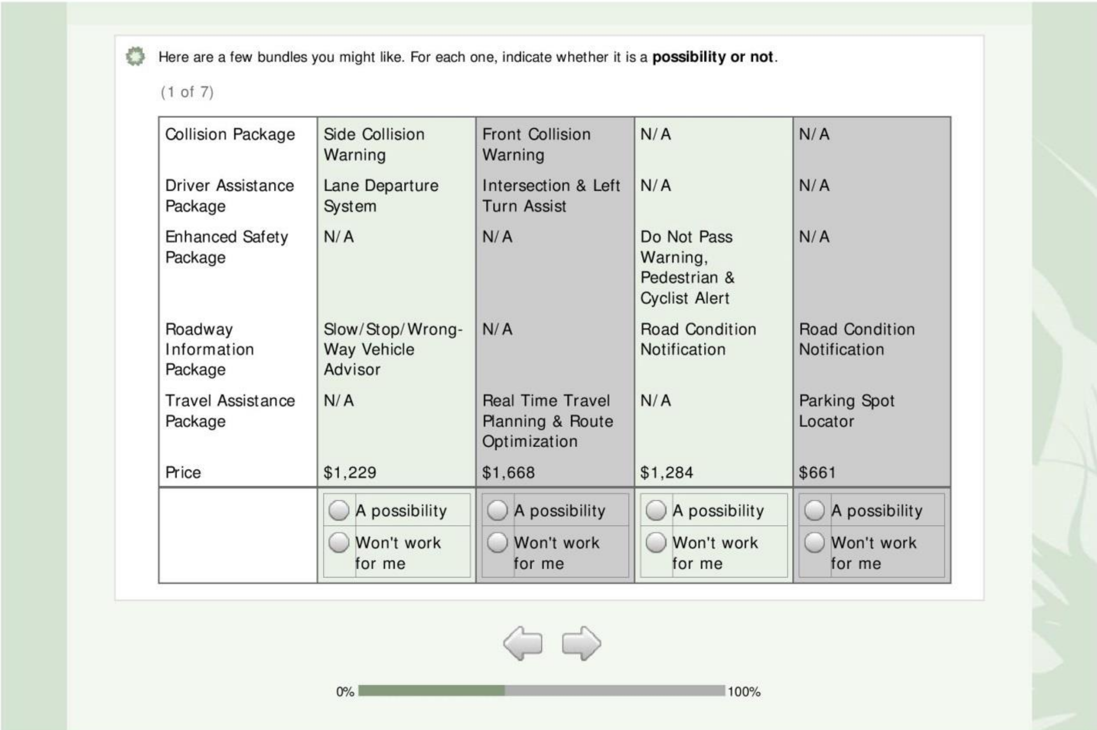
Image Sources [95, 96]



Please select the attributes you'd most likely include in your next vehicle. For each feature, select your preferred level.

Attribute	Select Feature	Cost for Feature
Collision Package	Select Feature	$
Driver Assistance Package	Select Feature	$
Enhanced Safety Package	Select Feature	$
Roadway Information Package	Select Feature	$
Travel Assistance Package	Select Feature	$
	Total	$

0% 100%



Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(1 of 7)

Collision Package	Side Collision Warning	Front Collision Warning	N/A	N/A
Driver Assistance Package	Lane Departure System	Intersection & Left Turn Assist	N/A	N/A
Enhanced Safety Package	N/A	N/A	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A
Roadway Information Package	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	Road Condition Notification	Road Condition Notification
Travel Assistance Package	N/A	Real Time Travel Planning & Route Optimization	N/A	Parking Spot Locator
Price	$1,229	$1,668	$1,284	$661
	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me

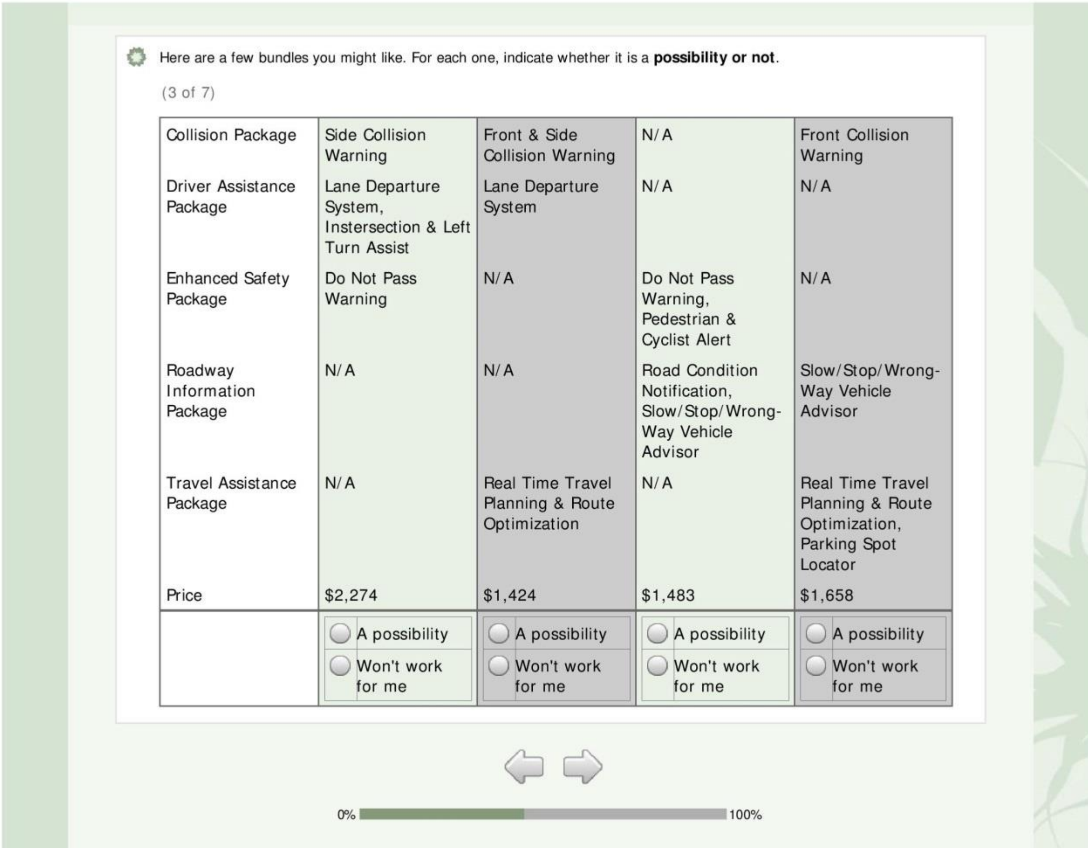
0% 100%

Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(2 of 7)

Collision Package	Side Collision Warning	Front Collision Warning	N/A	N/A
Driver Assistance Package	Lane Departure System	Intersection & Left Turn Assist	N/A	N/A
Enhanced Safety Package	N/A	N/A	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A
Roadway Information Package	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	Road Condition Notification	Road Condition Notification
Travel Assistance Package	N/A	Real Time Travel Planning & Route Optimization	N/A	Parking Spot Locator
Price	$1,229	$1,668	$1,284	$661
	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me

0% 100%



Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(3 of 7)

Collision Package	Side Collision Warning	Front & Side Collision Warning	N/A	Front Collision Warning
Driver Assistance Package	Lane Departure System, Instersection & Left Turn Assist	Lane Departure System	N/A	N/A
Enhanced Safety Package	Do Not Pass Warning	N/A	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A
Roadway Information Package	N/A	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	N/A	Real Time Travel Planning & Route Optimization	N/A	Real Time Travel Planning & Route Optimization, Parking Spot Locator
Price	$2,274	$1,424	$1,483	$1,658
	A possibility / Won't work for me	A possibility / Won't work for me	A possibility / Won't work for me	A possibility / Won't work for me

0% 100%

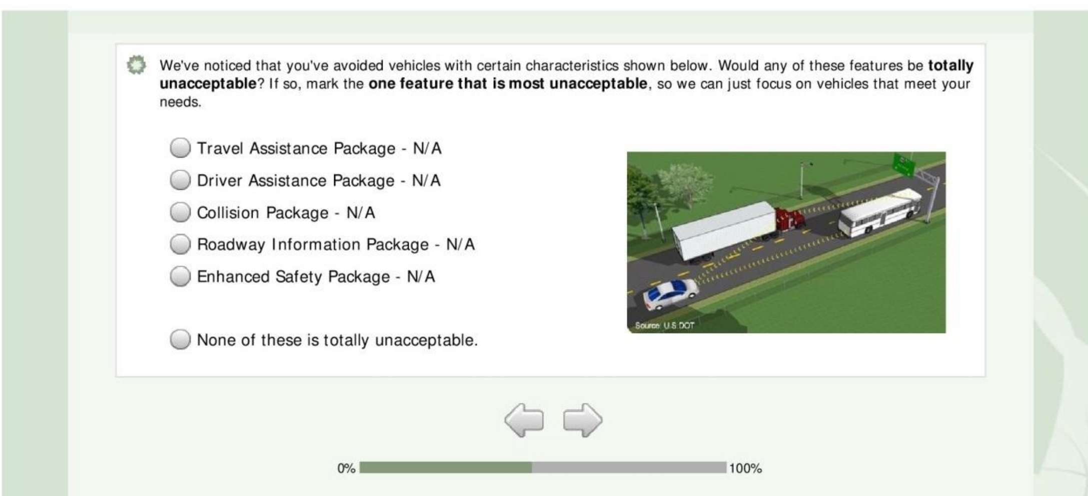


Image Source: [97]

Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(4 of 7)

Collision Package	Front Collision Warning	N/A	Front & Side Collision Warning	Side Collision Warning
Driver Assistance Package	Intersection & Left Turn Assist	N/A	Lane Departure System	N/A
Enhanced Safety Package	Pedestrian & Cyclist Alert	N/A	N/A	Do Not Pass Warning
Roadway Information Package	N/A	Road Condition Notification	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	N/A
Travel Assistance Package	N/A	Real Time Travel Planning & Route Optimization, Parking Spot Locator	N/A	N/A
Price	$1,306	$910	$2,502	$909
	A possibility / Won't work for me	A possibility / Won't work for me	A possibility / Won't work for me	A possibility / Won't work for me

0% 100%

We've noticed that you've avoided vehicles with certain characteristics shown below. Would any of these features be **totally unacceptable**? If so, mark the **one feature that is most unacceptable**, so we can just focus on vehicles that meet your needs.

- Roadway Information Package - N/A
- Enhanced Safety Package - N/A
- Driver Assistance Package - N/A
- Collision Package - N/A
- Travel Assistance Package - N/A

- None of these is totally unacceptable.

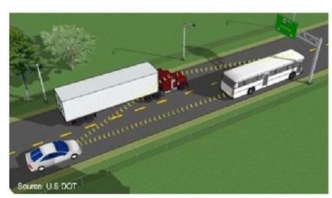


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Image Source: [97]

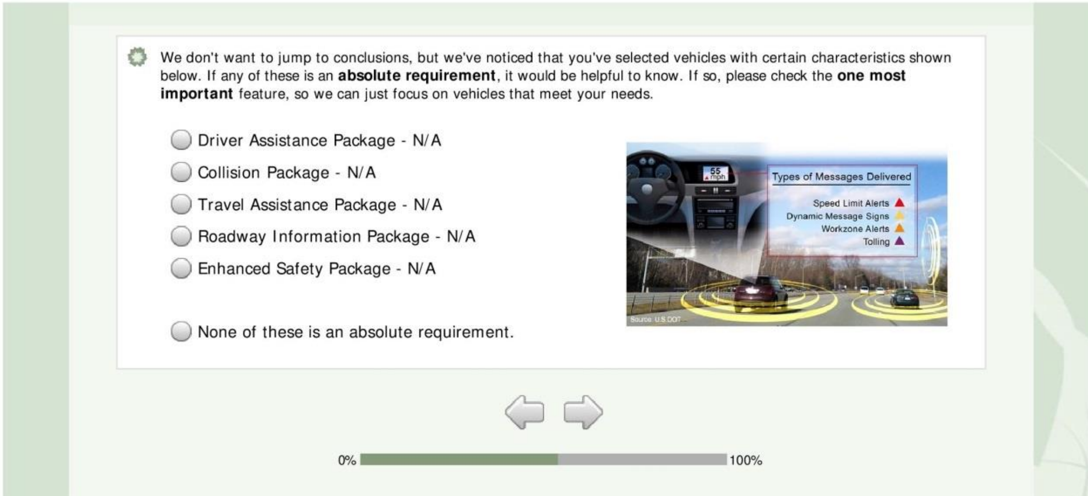
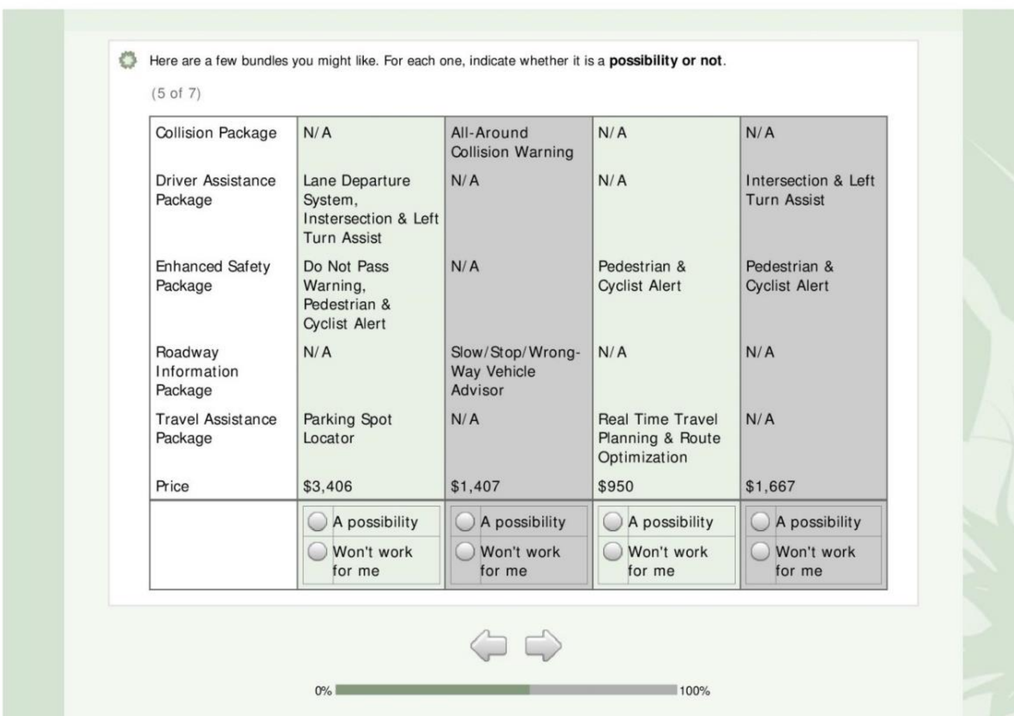


Image Source: [98]



Collision Package	N/A	All-Around Collision Warning	N/A	N/A
Driver Assistance Package	Lane Departure System, Instersection & Left Turn Assist	N/A	N/A	Intersection & Left Turn Assist
Enhanced Safety Package	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A	Pedestrian & Cyclist Alert	Pedestrian & Cyclist Alert
Roadway Information Package	N/A	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	N/A
Travel Assistance Package	Parking Spot Locator	N/A	Real Time Travel Planning & Route Optimization	N/A
Price	$3,406	$1,407	$950	$1,667
	A possibility / Won't work for me	A possibility / Won't work for me	A possibility / Won't work for me	A possibility / Won't work for me

Image Source: [97]

Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(5 of 7)

Collision Package	N/A	All-Around Collision Warning	N/A	N/A
Driver Assistance Package	Lane Departure System, Instersection & Left Turn Assist	N/A	N/A	Intersection & Left Turn Assist
Enhanced Safety Package	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A	Pedestrian & Cyclist Alert	Pedestrian & Cyclist Alert
Roadway Information Package	N/A	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	N/A
Travel Assistance Package	Parking Spot Locator	N/A	Real Time Travel Planning & Route Optimization	N/A
Price	$3,406	$1,407	$950	$1,667
	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me

0% 100%

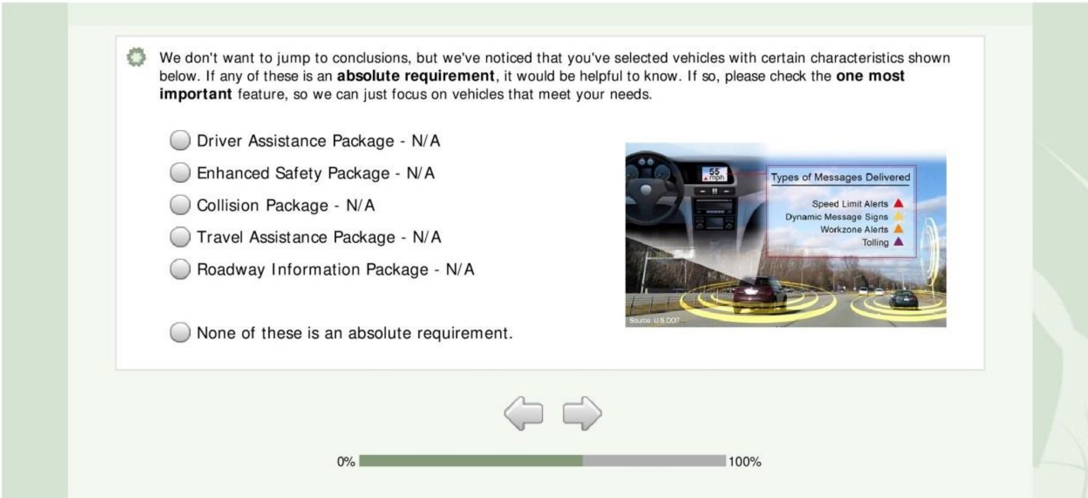
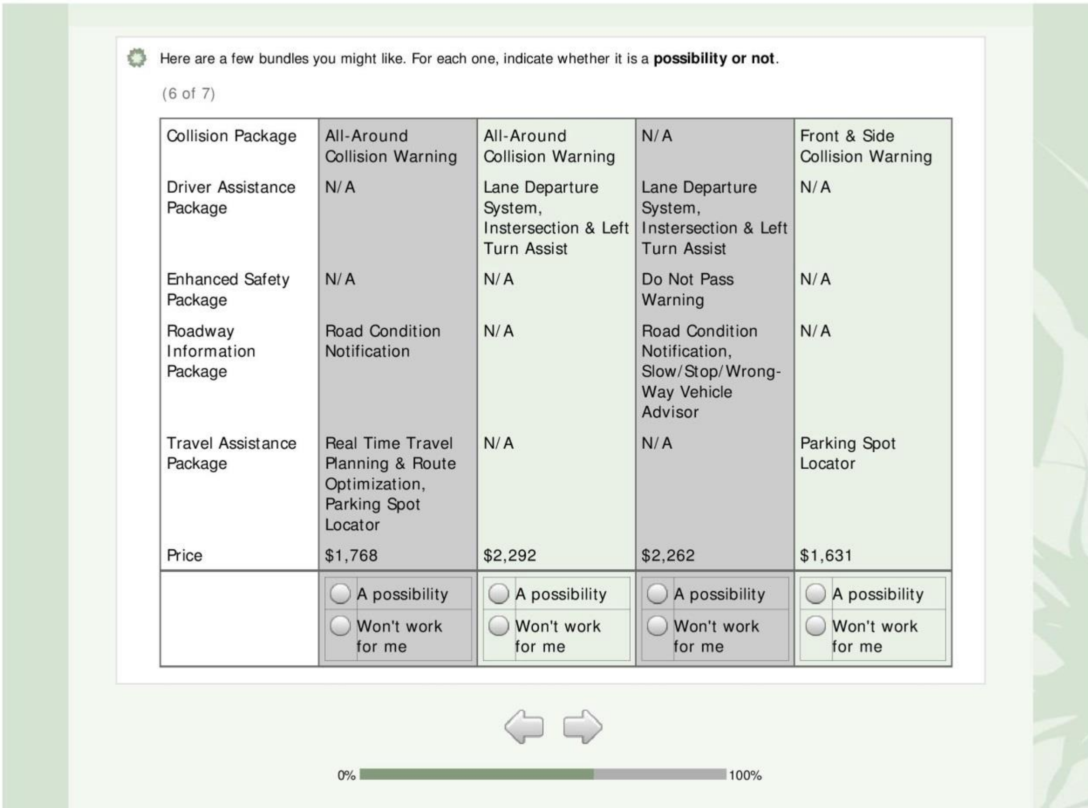


Image Source: [98]



Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(6 of 7)

Collision Package	All-Around Collision Warning	All-Around Collision Warning	N/A	Front & Side Collision Warning
Driver Assistance Package	N/A	Lane Departure System, Instersection & Left Turn Assist	Lane Departure System, Instersection & Left Turn Assist	N/A
Enhanced Safety Package	N/A	N/A	Do Not Pass Warning	N/A
Roadway Information Package	Road Condition Notification	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	N/A
Travel Assistance Package	Real Time Travel Planning & Route Optimization, Parking Spot Locator	N/A	N/A	Parking Spot Locator
Price	$1,768	$2,292	$2,262	$1,631
	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me

0% 100%

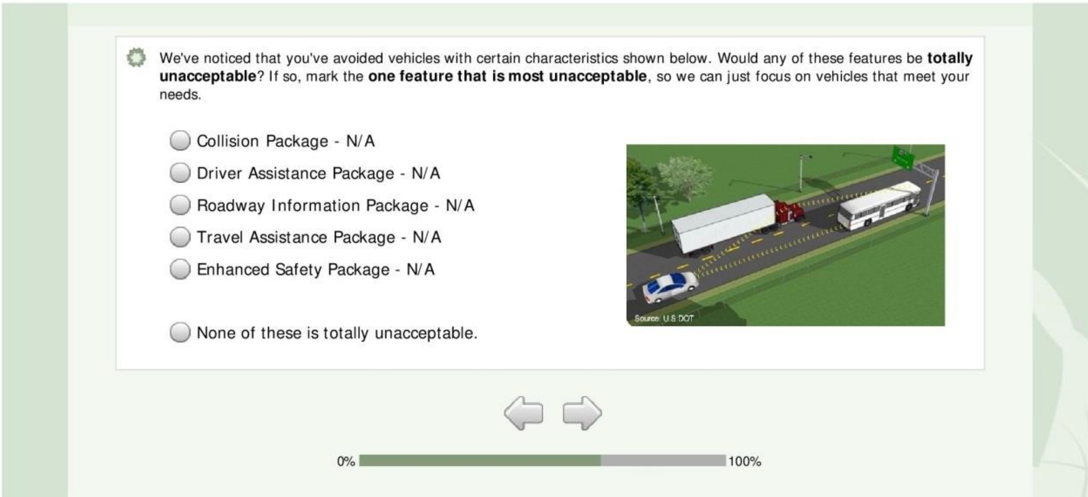


Image Source: [97]

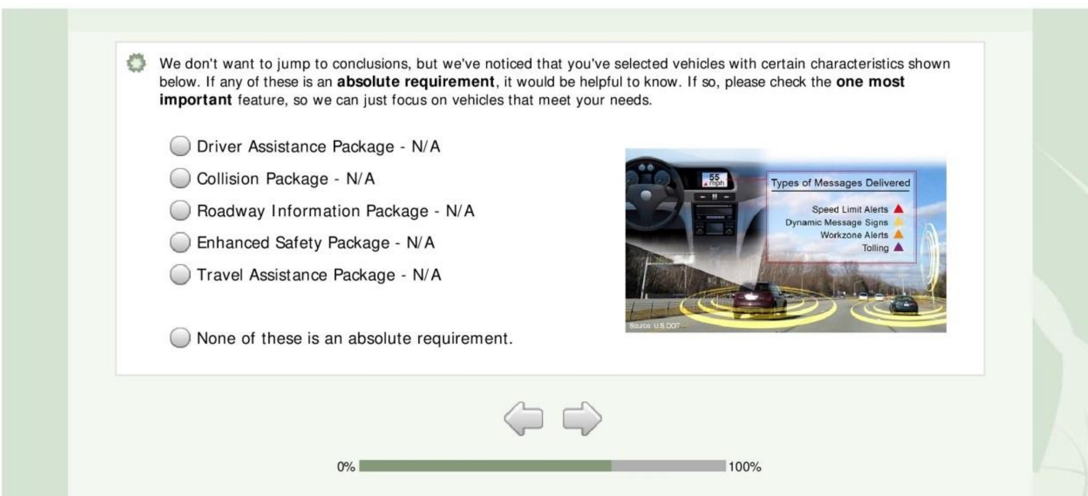


Image Source: [98]

Here are a few bundles you might like. For each one, indicate whether it is a **possibility or not**.

(7 of 7)

Collision Package	N/A	Front Collision Warning	Side Collision Warning	N/A
Driver Assistance Package	Lane Departure System	N/A	Intersection & Left Turn Assist	N/A
Enhanced Safety Package	Pedestrian & Cyclist Alert	N/A	Do Not Pass Warning	N/A
Roadway Information Package	N/A	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	Parking Spot Locator	N/A	N/A	Real Time Travel Planning & Route Optimization
Price	$1,491	$753	$1,653	$715
	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me	A possibility Won't work for me

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(1 of 8)

Collision Package	All-Around Collision Warning	N/A	Front & Side Collision Warning
Driver Assistance Package	N/A	Lane Departure System	N/A
Enhanced Safety Package	N/A	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A
Roadway Information Package	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	Real Time Travel Planning & Route Optimization, Parking Spot Locator	N/A	Parking Spot Locator
Price	$1,604	$1,908	$1,674
	○	○	○

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(2 of 8)

Collision Package	N/A	Front & Side Collision Warning	N/A
Driver Assistance Package	Lane Departure System	N/A	Intersection & Left Turn Assist
Enhanced Safety Package	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A	Do Not Pass Warning, Pedestrian & Cyclist Alert
Roadway Information Package	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	N/A
Travel Assistance Package	N/A	Parking Spot Locator	N/A
Price	$1,908	$1,674	$1,985

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(3 of 8)

Collision Package	Front & Side Collision Warning	N/A	N/A
Driver Assistance Package	N/A	Intersection & Left Turn Assist	N/A
Enhanced Safety Package	N/A	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A
Roadway Information Package	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	Parking Spot Locator	N/A	Real Time Travel Planning & Route Optimization
Price	$1,674	$1,985	$715

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(4 of 8)

Collision Package	N/A	N/A	Side Collision Warning
Driver Assistance Package	Intersection & Left Turn Assist	N/A	Intersection & Left Turn Assist
Enhanced Safety Package	Do Not Pass Warning, Pedestrian & Cyclist Alert	N/A	Do Not Pass Warning
Roadway Information Package	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	N/A
Travel Assistance Package	N/A	Real Time Travel Planning & Route Optimization	N/A
Price	$1,985	$715	$1,653
	○	○	○

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(5 of 8)

Collision Package	N/A	Side Collision Warning	Front Collision Warning
Driver Assistance Package	N/A	Intersection & Left Turn Assist	N/A
Enhanced Safety Package	N/A	Do Not Pass Warning	N/A
Roadway Information Package	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor	N/A	Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	Real Time Travel Planning & Route Optimization	N/A	N/A
Price	$715	$1,653	$753
	○	○	○

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(6 of 8)

Collision Package	Side Collision Warning	Front Collision Warning	N/A
Driver Assistance Package	Intersection & Left Turn Assist	N/A	Lane Departure System
Enhanced Safety Package	Do Not Pass Warning	N/A	Pedestrian & Cyclist Alert
Roadway Information Package	N/A	Slow/Stop/Wrong-Way Vehicle Advisor	N/A
Travel Assistance Package	N/A	N/A	Parking Spot Locator
Price	$1,653	$753	$1,491
	○	○	○

0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(7 of 8)

Collision Package	Front Collision Warning	N/A	Front & Side Collision Warning
Driver Assistance Package	N/A	Lane Departure System	N/A
Enhanced Safety Package	N/A	Pedestrian & Cyclist Alert	N/A
Roadway Information Package	Slow/Stop/Wrong-Way Vehicle Advisor	N/A	N/A
Travel Assistance Package	N/A	Parking Spot Locator	Parking Spot Locator
Price	$753	$1,491	$1,631
	○	○	○

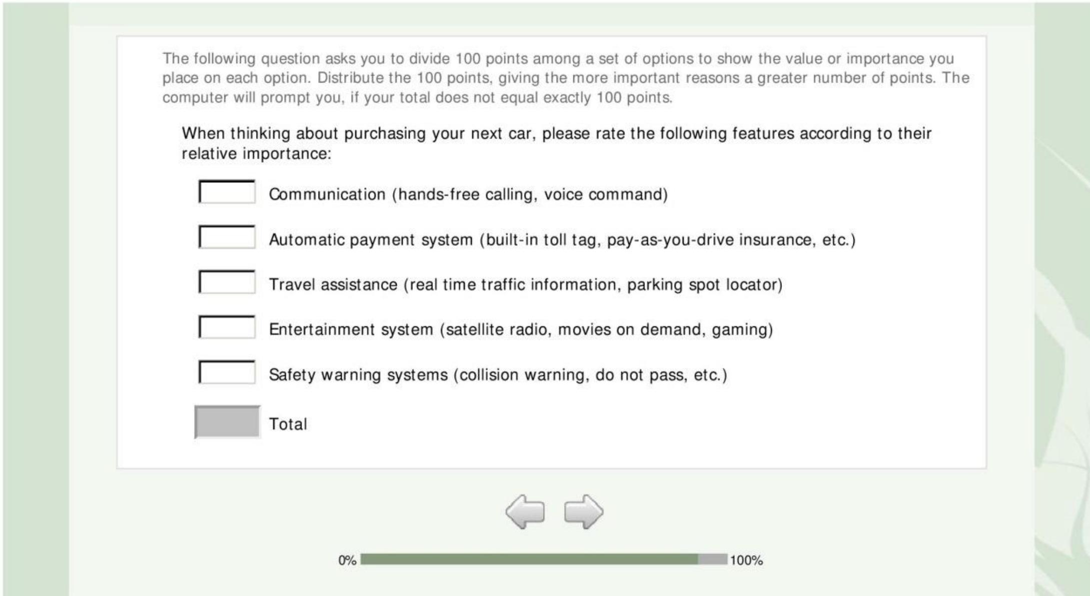
0% 100%

Among these three, which is the **best option**? (We've grayed out any features that are the same, so you can just focus on the differences.)

(8 of 8)

Collision Package	N/A	Front & Side Collision Warning	N/A
Driver Assistance Package	Lane Departure System	N/A	Lane Departure System, Instersection & Left Turn Assist
Enhanced Safety Package	Pedestrian & Cyclist Alert	N/A	Do Not Pass Warning
Roadway Information Package	N/A	N/A	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor
Travel Assistance Package	Parking Spot Locator	Parking Spot Locator	N/A
Price	$1,491	$1,631	$2,262
	○	○	○

0% 100%

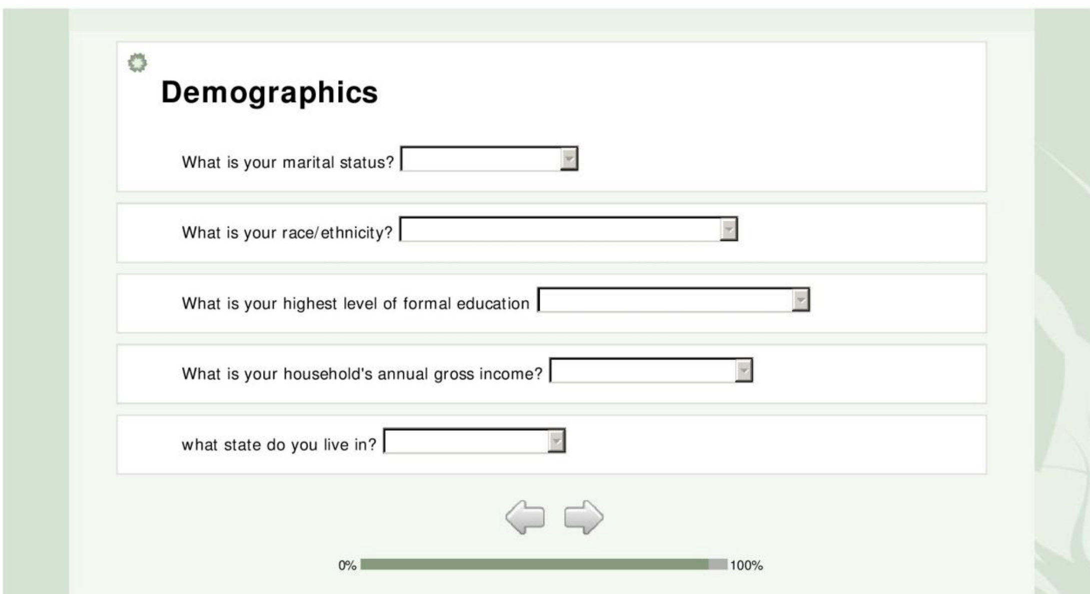


The following question asks you to divide 100 points among a set of options to show the value or importance you place on each option. Distribute the 100 points, giving the more important reasons a greater number of points. The computer will prompt you, if your total does not equal exactly 100 points.

When thinking about purchasing your next car, please rate the following features according to their relative importance:

- Communication (hands-free calling, voice command)
- Automatic payment system (built-in toll tag, pay-as-you-drive insurance, etc.)
- Travel assistance (real time traffic information, parking spot locator)
- Entertainment system (satellite radio, movies on demand, gaming)
- Safety warning systems (collision warning, do not pass, etc.)
- Total

0% 100%



Demographics

What is your marital status?

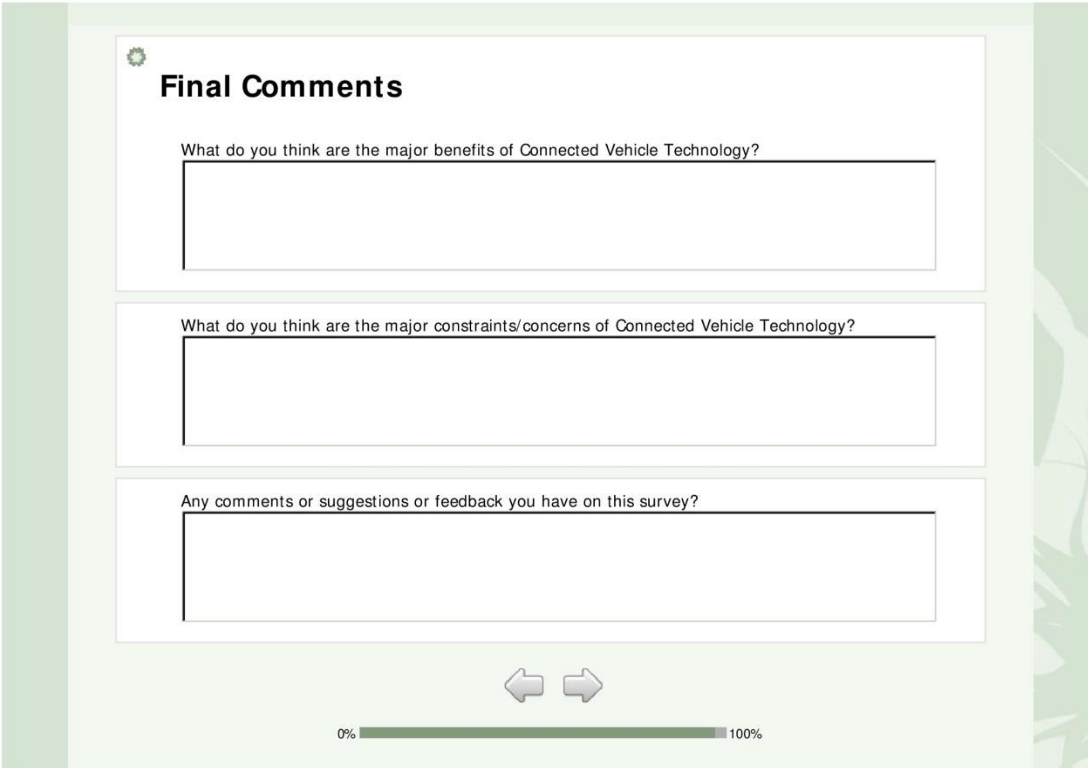
What is your race/ethnicity?

What is your highest level of formal education

What is your household's annual gross income?

what state do you live in?

0% 100%



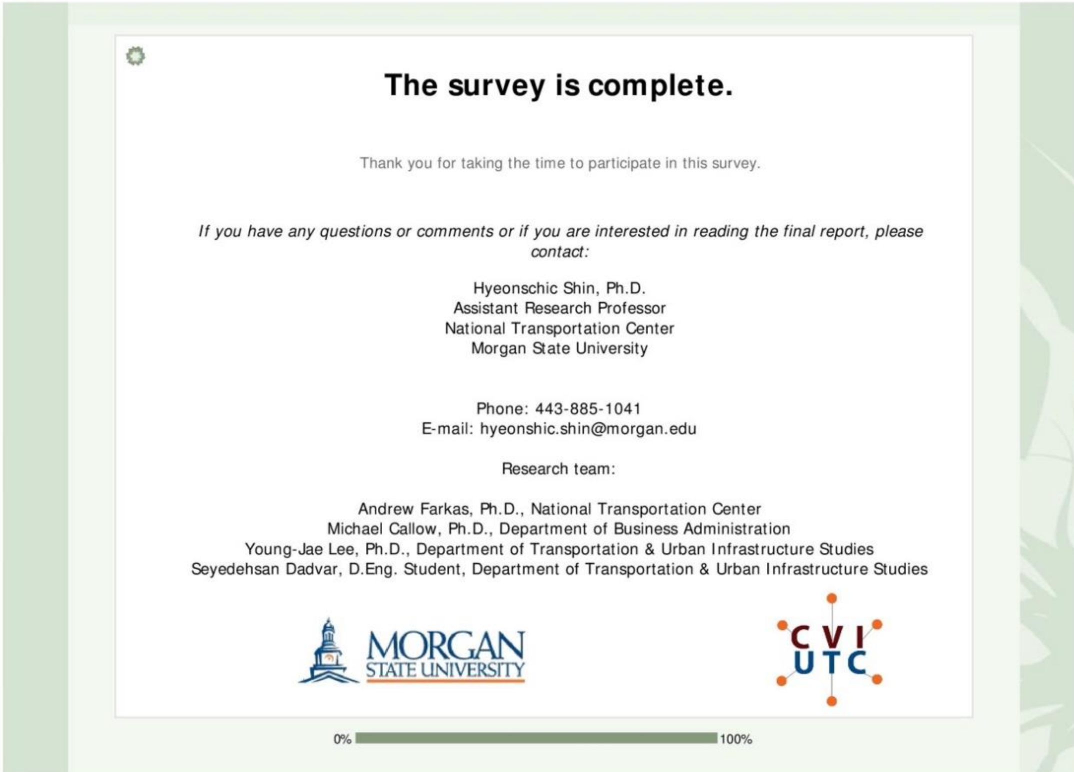
Final Comments

What do you think are the major benefits of Connected Vehicle Technology?

What do you think are the major constraints/concerns of Connected Vehicle Technology?

Any comments or suggestions or feedback you have on this survey?

0% 100%



The survey is complete.

Thank you for taking the time to participate in this survey.

If you have any questions or comments or if you are interested in reading the final report, please contact:

Hyeonschic Shin, Ph.D.
Assistant Research Professor
National Transportation Center
Morgan State University

Phone: 443-885-1041
E-mail: hyeonshic.shin@morgan.edu

Research team:

Andrew Farkas, Ph.D., National Transportation Center
Michael Callow, Ph.D., Department of Business Administration
Young-Jae Lee, Ph.D., Department of Transportation & Urban Infrastructure Studies
Seyedehsan Dadvar, D.Eng. Student, Department of Transportation & Urban Infrastructure Studies

MORGAN STATE UNIVERSITY

CVI UTC

0% 100%

Appendix F. Data Dictionary

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
RespNum	**RespNum**	**Respondent's number**	**Scale**
-	Number		
RecMeth	**RespNum**	**Recruitment method**	**Nominal**
0	1 - 1000	MSU Only	
1	1001 - 2000	Academic (Universities and colleges)	
2	2001 - 3000	LISTSERV	
3	3001- 4000	SNS Pages	
4	4001 - 5000	Craigslist	
5	5001 - 6000	Private Companies	
6	6001 - 7000	Government	
7	7001 - 8000	Personal (email contacts, friends, etc.)	
8	8001 - 9000	CVI-UTC	
9	9001 - 10000	NTC Friends/Supporters	
10	10001 - 11000	Public Schools	
11	11001 - 12000	ITS America	
12	12001 - 13000	Backpage	
Gender	**gender**	**Respondent's gender**	**Nominal**
1	Male		
2	Female		
Age	age	Respondent's age	Nominal
1	Under 20		
2	20 to 24 years old		
3	25 to 29 years old		
4	30 to 39 years old		
5	40 to 49 years old		
6	50 to 59 years old		
7	60 to 69 years old		
8	70 and older		
HHSize	**Household Size**	**Respondent's household size**	**Nominal**
1	I live by myself.		
2	1 additional person		
3	2 additional people		
4	3 additional people		
5	4 additional people		
6	5 additional people		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
7	6 additional people		
8	7 or more additional people		
Child_Num	**Child resident number**	**Number of children in household**	**Nominal**
1	None		
2	1 child		
3	2 children		
4	3 children		
5	4 children		
6	5 or more children		
Marital	**Marital**	**Respondent's marital status**	**Nominal**
1	Single		
2	Married		
3	Divorced/separated		
4	Widowed		
5	Other		
Race	**Race/ethnicity**	**Respondent's race/ethnicity**	**Nominal**
1	White (non-Hispanic)		
2	Hispanic		
3	Black or African American		
4	Asian		
5	American Indian or Alaska Native		
6	Native Hawaiian or other Pacific Islander		
7	Other		
Education	**education**	**Respondent's highest level of formal education**	**Nominal**
1	Some high school		
2	High school diploma		
3	Associate degree		
4	Bachelor's degree		
5	Master's degree		
6	Doctoral or postdoctoral degree		
Income	**income**	**Household's annual gross income**	**Nominal**
1	Less than $15,000		
2	$15,000 to $19,999		
3	$20,000 to $24,999		
4	$25,000 to $49,999		
5	$50,000 to $99,999		
6	$100,000 to $149,999		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
7	$150,000 to $199,999		
8	$200,000 or more		
Living State	**Living State**	**Respondent's living state**	**Nominal**
1	Alabama		
2	Alaska		
3	Arizona		
4	Arkansas		
5	California		
6	Colorado		
7	Connecticut		
8	Delaware		
9	District of Columbia		
10	Florida		
11	Georgia		
12	Hawaii		
13	Idaho		
14	Illinois		
15	Indiana		
16	Iowa		
17	Kansas		
18	Kentucky		
19	Louisiana		
20	Maine		
21	Maryland		
22	Massachusetts		
23	Michigan		
24	Minnesota		
25	Mississippi		
26	Missouri		
27	Montana		
28	Nebraska		
29	Nevada		
30	New Hampshire		
31	New Jersey		
32	New Mexico		
33	New York		
34	North Carolina		
35	North Dakota		
36	Ohio		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
37	Oklahoma		
38	Oregon		
39	Pennsylvania		
40	Rhode Island		
41	South Carolina		
42	South Dakota		
43	Tennessee		
44	Texas		
45	Utah		
46	Vermont		
47	Virginia		
48	Washington		
49	West Virginia		
50	Wisconsin		
51	Wyoming		
52	Other US territories		
53	Not Applicable		
Veh_Num	**carusage1**	**Number of vehicles in household**	**Nominal**
1	None		
2	One		
3	Two		
4	Three or more		
Veh_Use	**carusage2**	**Primary use of the vehicle**	**Nominal**
1	Work		
2	Study		
3	Recreation		
4	Shopping and running errands		
5	Picking up and dropping off family members		
6	Other		
7	Not Applicable		
Veh_DaysWeek	**carusage3**	**Average number of days using the vehicle per week**	**Nominal**
1	0 to 2 days		
2	3 to 4 days		
3	5 to 7 days		
4	Not Applicable		
Veh_MilesWeek	**cCarmiles**	**Average miles using the vehicle per day**	**Nominal**
1	Less than 5 miles		
2	5 to 15 miles		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
3	16 to 25 miles		
4	26 to 50 miles		
5	More than 50 miles		
6	Not Applicable		
Veh_HrsDay	**carhours**	**Average hours using the vehicle per day**	**Nominal**
1	Less than 0.5 hour		
2	0.5 to 1 hour		
3	1 to 1.5 hours		
4	1.5 to 2 hours		
5	More than 2 hours		
6	Not Applicable		
Diff1_Navigation	**Diffusion**	**Availability of Navigation System**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff2_Handsfree	**Diffusion**	**Availability of Hands-free calling (e.g., Bluetooth)**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff3_HEFuel	**Diffusion**	**Availability of Hybrid or electric fuel technology**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff4_ParkAssist	**Diffusion**	**Availability of Parking assistance technology**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff5_BackupWarn	**Diffusion**	**Availability of Back up warning system**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
Diff6_BackupCam	**Diffusion**	**Availability of Back up camera**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff7_LaneDepWarn	**Diffusion**	**Availability of Lane departure warning system**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff8_VideoEnt	**Diffusion**	**Availability of Video entertainment system**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Diff9_SatHDRadio	**Diffusion**	**Availability of Satellite or HD radio**	**Nominal**
1	Available in my current car		
2	Not sure it's available in my current car		
3	Not available in my car, but considering getting in my next car		
4	Not available in my car, not planning on getting in my next car		
Current_Veh_Ty	**newcar**	**Current vehicle type**	**Nominal**
1	Sedan or coupe		
2	SUV		
3	Truck		
4	Minivan		
5	Luxury vehicle		
6	Station wagon		
7	Convertible		
8	Van		
9	Crossover		
10	Sports car		
11	Other		
12	Not sure		
Current_Veh_Eng_Ty	**enginetype1**	**Current vehicle engine type**	**Nominal**
1	Gas		
2	Hybrid		
3	Electric		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
4	Diesel		
5	Not sure		
Next_Veh_Ty	**newcar1**	**Next vehicle type**	**Nominal**
1	Sedan or coupe		
2	SUV		
3	Truck		
4	Minivan		
5	Luxury vehicle		
6	Station wagon		
7	Convertible		
8	Van		
9	Crossover		
10	Sports car		
11	Other		
12	Not sure		
Next_Veh_Eng_Ty	**engine type**	**Next vehicle engine type**	**Nominal**
1	Gas		
2	Hybrid		
3	Electric		
4	Diesel		
5	Not sure		
Next_Veh_Own_Ty	**newcar2**	**Next vehicle type of purchase/lease**	**Nominal**
1	Purchase New Vehicle		
2	Lease New Vehicle		
3	Purchase Used Vehicle		
4	Lease Used Vehicle		
5	Rent a car as necessary		
Next_Veh_MinVal	**newcar3**	**Respondent's minimum value to spend for the next vehicle**	**Nominal**
1	$5,000 or less		
2	$10,000		
3	$15,000		
4	$20,000		
5	$25,000		
6	$30,000		
7	$35,000		
8	$40,000		
9	$45,000		
10	$50,000		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
11	$55,000		
12	$60,000		
13	$65,000		
14	$70,000		
15	More than $70,000		
Next_Veh_MaxVal	**newcar4**	**Respondent's maximum value to spend for the next vehicle**	**Nominal**
1	$5,000 or less		
2	$10,000		
3	$15,000		
4	$20,000		
5	$25,000		
6	$30,000		
7	$35,000		
8	$40,000		
9	$45,000		
10	$50,000		
11	$55,000		
12	$60,000		
13	$65,000		
14	$70,000		
15	$75,000		
16	$80,000		
17	$90,000		
18	$95,000		
19	$100,000		
20	More than $100,000		
Gen1_BuyExp	**Gender1**	**Respondent's level of involvement with the purchase or lease of the current driving vehicle**	**Nominal**
1	I was the sole decision-maker		
2	I was an active participant (50/50) in the decision-making process		
3	I was a minor participant in the decision-making process		
4	I was not at all involved		
Gen2_AskRelative	**Gender2**	**Respondent's idea about asking relatives or friends to purchase or lease a vehicle**	**Ordinal**
1	Strongly Agree		
2	Somewhat Agree		
3	Neither Agree nor Disagree		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
4	Somewhat Disagree		
5	Strongly Disagree		
Gen3_CarDealership	**Gender3**	**Respondent's idea about never going to a car dealership alone to purchase or lease a vehicle**	**Ordinal**
1	Strongly Agree		
2	Somewhat Agree		
3	Neither Agree nor Disagree		
4	Somewhat Disagree		
5	Strongly Disagree		
Gen4_KnowWhatDoing	**Gender4**	**Respondent's idea about knowing what you're doing when it comes to purchase or lease a vehicle**	**Nominal**
1	Strongly Agree		
2	Somewhat Agree		
3	Neither Agree nor Disagree		
4	Somewhat Disagree		
5	Strongly Disagree		
CarChar1_Safety	**car characteristics**	**Importance of Safety to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar2_ExDesign	**car characteristics**	**Importance of Exterior Design to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar3_MtrPwr	**car characteristics**	**Importance of Motor Power to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar4_Status	**car characteristics**	**Importance of Status to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
4	Not important at all		
CarChar5_DrivingComf	**car characteristics**	**Importance of Driving Comfort to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar6_InSpace	**car characteristics**	**Importance of Interior Space to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar7_FuelConsum	**car characteristics**	**Importance of Fuel Consumption to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar8_Reliability	**car characteristics**	**Importance of Reliability to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CarChar9_EnvImp	**car characteristics**	**Importance of Environmental Impacts to purchase or lease a vehicle**	**Nominal**
1	Very important		
2	Fairly important		
3	Fairly unimportant		
4	Not important at all		
CVKnowledge	**cvknowledge**	**Respondent's knowledge about Connected Vehicle Technology**	**Nominal**
1	I am knowledgeable about connected vehicles		
2	I know a little bit about connected vehicles		
3	I have heard the term "connected vehicles" but I do not know what it means		
4	I have never heard about connected vehicles before this survey		
BYO1_CollisionPkg	**ABC_BYO**	**Respondent's selection from Collision Package**	**Ordinal**
1	N/A		
2	Front Collision Warning		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
3	Side Collision Warning		
4	Front & Side Collision Warning		
5	All-Around Collision Warning		
BYO2_DriverAssistPkg	**ABC_BYO**	**Respondent's selection from Driver Assistance Package**	**Ordinal**
1	N/A		
2	Lane Departure System		
3	Intersection & Left Turn Assist		
4	Lane Departure System, Intersection & Left Turn Assist		
BYO3_EnhancedSafePkg	**ABC_BYO**	**Respondent's selection from Enhanced Safety Package**	**Ordinal**
1	N/A		
2	Do Not Pass Warning		
3	Pedestrian & Cyclist Alert		
4	Do Not Pass Warning, Pedestrian & Cyclist Alert		
BYO4_RdInfoPkg	**ABC_BYO**	**Respondent's selection from Roadway Information Package**	**Ordinal**
1	N/A		
2	Road Condition Notification		
3	Slow/Stop/Wrong-Way Vehicle Advisor		
4	Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor		
BYO5_TravelAssitPkg	**ABC_BYO**	**Respondent's selection from Travel Assistance Package**	**Ordinal**
1	N/A		
2	Real Time Travel Planning & Route Optimization		
3	Parking Spot Locator		
4	Real Time Travel Planning & Route Optimization, Parking Spot Locator		
BYO_Price	**ABC_BYO**	**Respondent's total price spent at build your own (BYO) section**	**Scale**
-	$0-$4500		
ConstSum1_Safety	**Constantsumchoice**	**Respondent's rate for Safety warning systems (collision warning, do not pass, etc.)**	**Scale**
	0-100		
ConstSum2_TravelAssist	**Constantsumchoice**	**Respondent's rate for Travel assistance (real time traffic information, parking spot locator)**	**Scale**
	0-100		
ConstSum3_Entertain	**Constantsumchoice**	**Respondent's rate for Entertainment system (satellite radio, movies on demand, gaming)**	**Scale**

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
	0-100		
ConstSum4_Communicate	**Constantsumchoice**	**Respondent's rate for Communication (hands-free calling, voice command)**	**Scale**
	0-100		
ConstSum5_AutoPayment	**Constantsumchoice**	**Respondent's rate for Automatic payment system (built-in toll tag, pay-as-you-drive insurance, etc.)**	**Scale**
	0-100		
Ut_Collision1_NA	**N/A**	**Individual Utility for Collision Package: Level 1 [NA]**	**Scale**
	Number		
Ut_Collision2_Front	**Front Collision Warning**	**Individual Utility for Collision Package: Level 2 [Front Collision Warning]**	**Scale**
	Number		
Ut_Collision3_Side	**Side Collision Warning**	**Individual Utility for Collision Package: Level 3 [Side Collision Warning]**	**Scale**
	Number		
Ut_Collision4_FrontSide	**Front & Side Collision Warning**	**Individual Utility for Collision Package: Level 4 [Front & Side Collision Warning]**	**Scale**
	Number		
Ut_Collision5_All	**All-Around Collision Warning**	**Individual Utility for Collision Package: Level 5 [All]**	**Scale**
	Number		
Ut_DriverAssist1_NA	**N/A**	**Individual Utility for Driver Assistance Package: Level 1 [NA]**	**Scale**
	Number		
Ut_DriverAssist2_LaDepSys	**Lane Departure System**	**Individual Utility for Driver Assistance Package: Level 2 [Lane Departure System]**	**Scale**
	Number		
Ut_DriverAssist3_IntLTA	**Intersection & Left Turn Assist**	**Individual Utility for Driver Assistance Package: Level 3 [Intersection & Left Turn Assist]**	**Scale**
	Number		
Ut_DriverAssist4_All	**Lane Departure System, Intersection & Left Turn Assist**	**Individual Utility for Driver Assistance Package: Level 4 [All]**	**Scale**
	Number		
Ut_EnhancedSafe1_NA	**N/A**	**Individual Utility for Enhanced Safety Package: Level 1 [NA]**	**Scale**
	Number		

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
Ut_EnhancedSafe2_DNPW	**Do Not Pass Warning**	**Individual Utility for Enhanced Safety Package: Level 2 [Do Not Pass Warning]**	**Scale**
	Number		
Ut_EnhancedSafe3_PCA	**Pedestrian & Cyclist Alert**	**Individual Utility for Enhanced Safety Package: Level 3 [Pedestrian & Cyclist Alert]**	**Scale**
	Number		
Ut_EnhancedSafe4_All	**Do Not Pass Warning, Pedestrian & Cyclist Alert**	**Individual Utility for Enhanced Safety Package: Level 4 [All]**	**Scale**
	Number		
Ut_RdInfo1_NA	**N/A**	**Individual Utility for Roadway Information Package: Level 1 [NA]**	**Scale**
	Number		
Ut_RdInfo2_RCN	**Road Condition Notification**	**Individual Utility for Roadway Information Package: Level 2 [Road Condition Notification]**	**Scale**
	Number		
Ut_RdInfo3_VehAdv	**Slow/Stop/Wrong-Way Vehicle Advisor**	**Individual Utility for Roadway Information Package: Level 3 [Slow/Stop/Wrong-Way Vehicle Advisor]**	**Scale**
	Number		
Ut_RdInfo4_All	**Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor**	**Individual Utility for Roadway Information Package: Level 4 [All]**	**Scale**
	Number		
Ut_TravelAssist1_NA	**N/A**	**Individual Utility for Travel Assistance Package: Level 1 [NA]**	**Scale**
	Number		
Ut_TravelAssist2_RealTime	**Real Time Travel Planning & Route Optimization**	**Individual Utility for Travel Assistance Package: Level 2 [Real Time Travel Planning & Route Optimization]**	**Scale**
	Number		
Ut_TravelAssist3_PSL	**Parking Spot Locator**	**Individual Utility for Travel Assistance Package: Level 3 [Parking Spot Locator]**	**Scale**
	Number		
Ut_TravelAssist4_All	**Real Time Travel Planning & Route Optimization, Parking Spot Locator**	**Individual Utility for Travel Assistance Package: Level 4 [All]**	**Scale**
	Number		
Ut_Price_0	**Price: 0**	**Individual Utility for Price: 0**	**Scale**
	Number		
Ut_Price_1572	**Price: 1572**	**Individual Utility for Price: 1572**	**Scale**

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
	Number		
Ut_Price_2433	**Price: 2433**	**Individual Utility for Price: 2433**	**Scale**
	Number		
Ut_Price_3381	**Price: 3381**	**Individual Utility for Price: 3381**	**Scale**
	Number		
Ut_Price_5850	**Price: 5850**	**Individual Utility for Price: 5850**	**Scale**
	Number		
Ut_Base	**Base_Utility**	**Individual Base Utility**	**Scale**
	Number		
Imp_CollisionPkg	**Collision Package**	**Individual Importance for Collision Package**	**Scale**
	Number		
Imp_DriverAssistPkg	**Driver Assistance Package**	**Individual Importance for Driver Assistance Package**	**Scale**
	Number		
Imp_EnhancedSafePkg	**Enhanced Safety Package**	**Individual Importance for Enhanced Safety Package**	**Scale**
	Number		
Imp_RdInfoPkg	**Roadway Information Package**	**Individual Importance for Roadway Information Package**	**Scale**
	Number		
Imp_TravelAssistPkg	**Travel Assistance Package**	**Individual Importance for Travel Assistance Package**	**Scale**
	Number		
Imp_Price	**Price**	**Individual Importance for Price**	**Scale**
	Number		
Tour_Collision1_NA	**Tournament Winner Collision Package: N/A**	**Tournament Winner for Collision Package: Level 1 [NA]**	**Nominal**
	0 or 1		
Tour_Collision2_Front	**Tournament Winner Collision Package: Front Collision Warning**	**Tournament Winner for Collision Package: Level 2 [Front Collision Warning]**	**Nominal**
	0 or 1		
Tour_Collision3_Side	**Tournament Winner Collision Package: Side Collision Warning**	**Tournament Winner for Collision Package: Level 3 [Side Collision Warning]**	**Nominal**
	0 or 1		
Tour_Collision4_FrontSide	**Tournament Winner Collision Package: Front & Side Collision Warning**	**Tournament Winner for Collision Package: Level 4 [Front & Side Collision Warning]**	**Nominal**
	0 or 1		
Tour_Collision5_All	**Tournament Winner Collision Package: All-Around Collision Warning**	**Tournament Winner for Collision Package: Level 5 [All]**	**Nominal**

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
	0 or 1		
Tour_DriverAssist1_NA	**Tournament Winner Driver Assistance Package: N/A**	**Tournament Winner for Driver Assistance Package: Level 1 [NA]**	**Nominal**
	0 or 1		
Tour_DriverAssist2_LaDepSys	**Tournament Winner Driver Assistance Package: Lane Departure System**	**Tournament Winner for Driver Assistance Package: Level 2 [Lane Departure System]**	**Nominal**
	0 or 1		
Tour_DriverAssist3_IntLTA	**Tournament Winner Driver Assistance Package: Intersection & Left Turn Assist**	**Tournament Winner for Driver Assistance Package: Level 3 [Intersection & Left Turn Assist]**	**Nominal**
	0 or 1		
Tour_DriverAssist4_All_A	**Tournament Winner Driver Assistance Package: Lane Departure System, Intersection & Left Turn Assist**	**Tournament Winner for Driver Assistance Package: Level 4 [All]**	**Nominal**
	0 or 1		
Tour_EnhancedSafe1_NA	**Tournament Winner Enhanced Safety Package: N/A**	**Tournament Winner for Enhanced Safety Package: Level 1 [NA]**	**Nominal**
	0 or 1		
Tour_EnhancedSafe2_DNPW	**Tournament Winner Enhanced Safety Package: Do Not Pass Warning**	**Tournament Winner for Enhanced Safety Package: Level 2 [Do Not Pass Warning]**	**Nominal**
	0 or 1		
Tour_EnhancedSafe3_PCA	**Tournament Winner Enhanced Safety Package: Pedestrian & Cyclist Alert**	**Tournament Winner for Enhanced Safety Package: Level 3 [Pedestrian & Cyclist Alert]**	**Nominal**
	0 or 1		
Tour_EnhancedSafe4_All	**Tournament Winner Enhanced Safety Package: Do Not Pass Warning, Pedestrian & Cyclist Alert**	**Tournament Winner for Enhanced Safety Package: Level 4 [All]**	**Nominal**
	0 or 1		
Tour_RdInfo1_NA	**Tournament Winner Roadway Information Package: N/A**	**Tournament Winner for Roadway Information Package: Level 1 [NA]**	**Nominal**
	0 or 1		
Tour_RdInfo2_RCN	**Tournament Winner Roadway Information Package: Road Condition Notification**	**Tournament Winner for Roadway Information Package: Level 2 [Road Condition Notification]**	**Nominal**
	0 or 1		
Tour_RdInfo3_VehAdv	**Tournament Winner Roadway Information**	**Tournament Winner for Roadway Information Package:**	**Nominal**

Variable name in SPSS/Codes	Question/section name in Sawtooth	Label in SPSS	Measure
	Package: Slow/Stop/Wrong-Way Vehicle Advisor	**Level 3 [Slow/Stop/Wrong-Way Vehicle Advisor]**	
	0 or 1		
Tour_RdInfo4_All	**Tournament Winner Roadway Information Package: Road Condition Notification, Slow/Stop/Wrong-Way Vehicle Advisor**	**Tournament Winner for Roadway Information Package: Level 4 [All]**	**Nominal**
	0 or 1		
Tour_TravelAssist1_NA	**Tournament Winner Travel Assistance Package: N/A**	**Tournament Winner for Travel Assistance Package: Level 1 [NA]**	**Nominal**
	0 or 1		
Tour_TravelAssist2_RealTime	**Tournament Winner Travel Assistance Package: Real Time Travel Planning & Route Optimization**	**Tournament Winner for Travel Assistance Package: Level 2 [Real Time Travel Planning & Route Optimization]**	**Nominal**
	0 or 1		
Tour_TravelAssist3_PSL	**Tournament Winner Travel Assistance Package: Parking Spot Locator**	**Tournament Winner for Travel Assistance Package: Level 3 [Parking Spot Locator]**	**Nominal**
	0 or 1		
Tour_TravelAssist4_All	**Tournament Winner Travel Assistance Package: Real Time Travel Planning & Route Optimization, Parking Spot Locator**	**Tournament Winner for Travel Assistance Package: Level 4 [All]**	**Nominal**
	0 or 1		
TourWinPrice	**Tournament Winner Price**	**Tournament Winner for Price**	**Scale**
	$0-$5850		

Appendix G. Reliability Test for Purchasing Involvement Questions

Cronbach's alpha is a commonly used evaluation of the reliability of a psychometric test for a sample of examinees. It is a coefficient of internal consistency and is used for evaluation of the unidimensionality of a set of scale items. It measures how all variables in a predefined scale are positively related to each other and is an adjustment to the average correlation between variables (every variable and every other one) [99]. Nunnally [100] offered a rule of thumb of 0.7. More recently, one tends to see 0.8 cited as a minimum alpha.

Using IBM SPSS 22 Cronbach's alpha calculation (Analyze ➔ Scale ➔ Reliability Analysis; selecting variables and model as "Alpha") for questions related to purchasing involvement resulted in α = 0.657, which is almost acceptable.

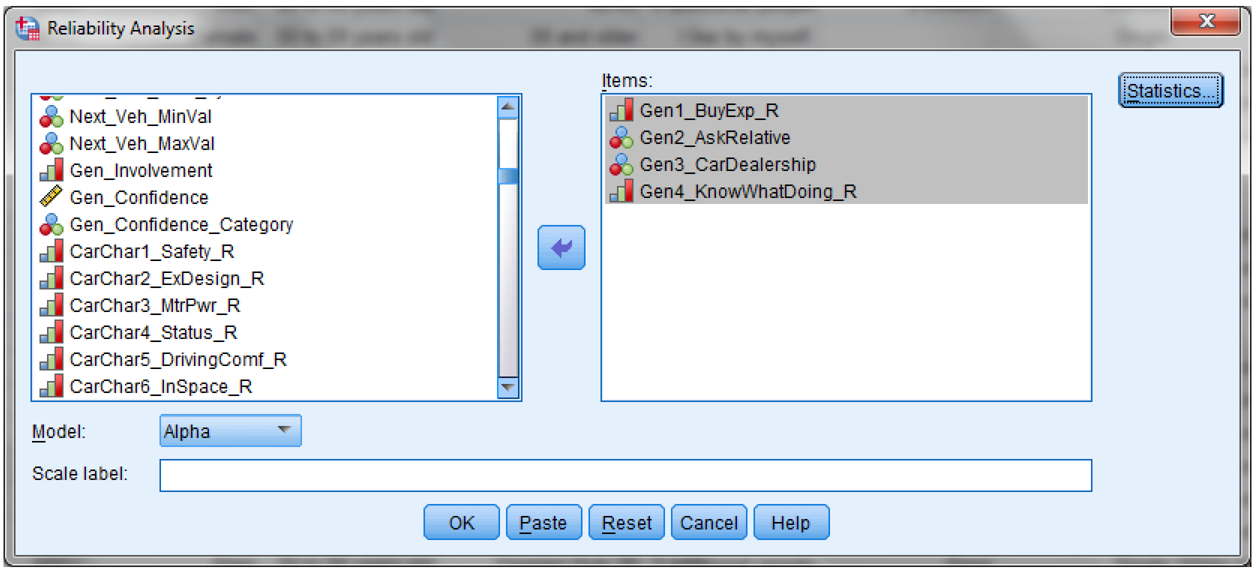


Figure 14. Reliability analysis window in IBM SPSS 22 for purchasing involvement questions.

IBM SPSS Output

Scale: ALL VARIABLES

Table 14. Case Processing Summary

		N	percent
Cases	Valid	590	96.6
	Excluded[a]	21	3.4
	Total	611	100.0

a. Listwise deletion based on all variables in the procedure.

Table 15. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.648	.657	4

Table 16. Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum/ Minimum	Variance	N of Items
Item Means	3.261	2.842	3.890	1.047	1.369	.238	4
Item Variances	1.655	.750	2.442	1.692	3.255	.559	4
Inter-Item Covariances	.521	.250	.913	.663	3.649	.053	4
Inter-Item Correlations	.324	.202	.407	.206	2.022	.005	4

Appendix H. Word Clouds for Open-Ended Questions

Figure 15. Word cloud for "Benefits," CV Knowledge = 3 (knowledgeable).

Figure 16. Word cloud for “Benefits,” CV Knowledge = 2 (limited knowledge).

Figure 17. Word cloud for "Benefits," CV knowledge = 1 (no knowledge).

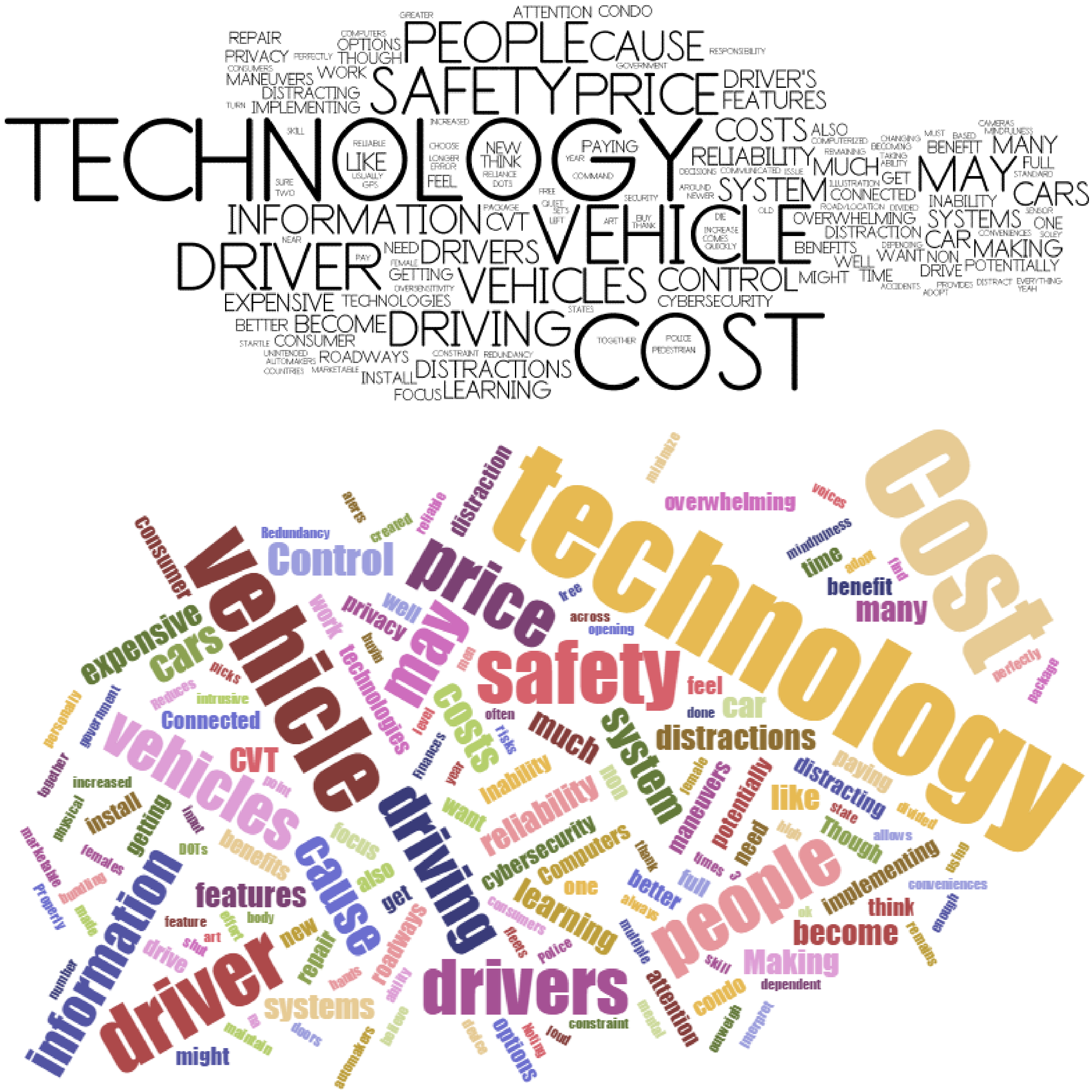


Figure 18. Word cloud for "Constraints/Concerns," CV Knowledge = 3 (knowledgeable).

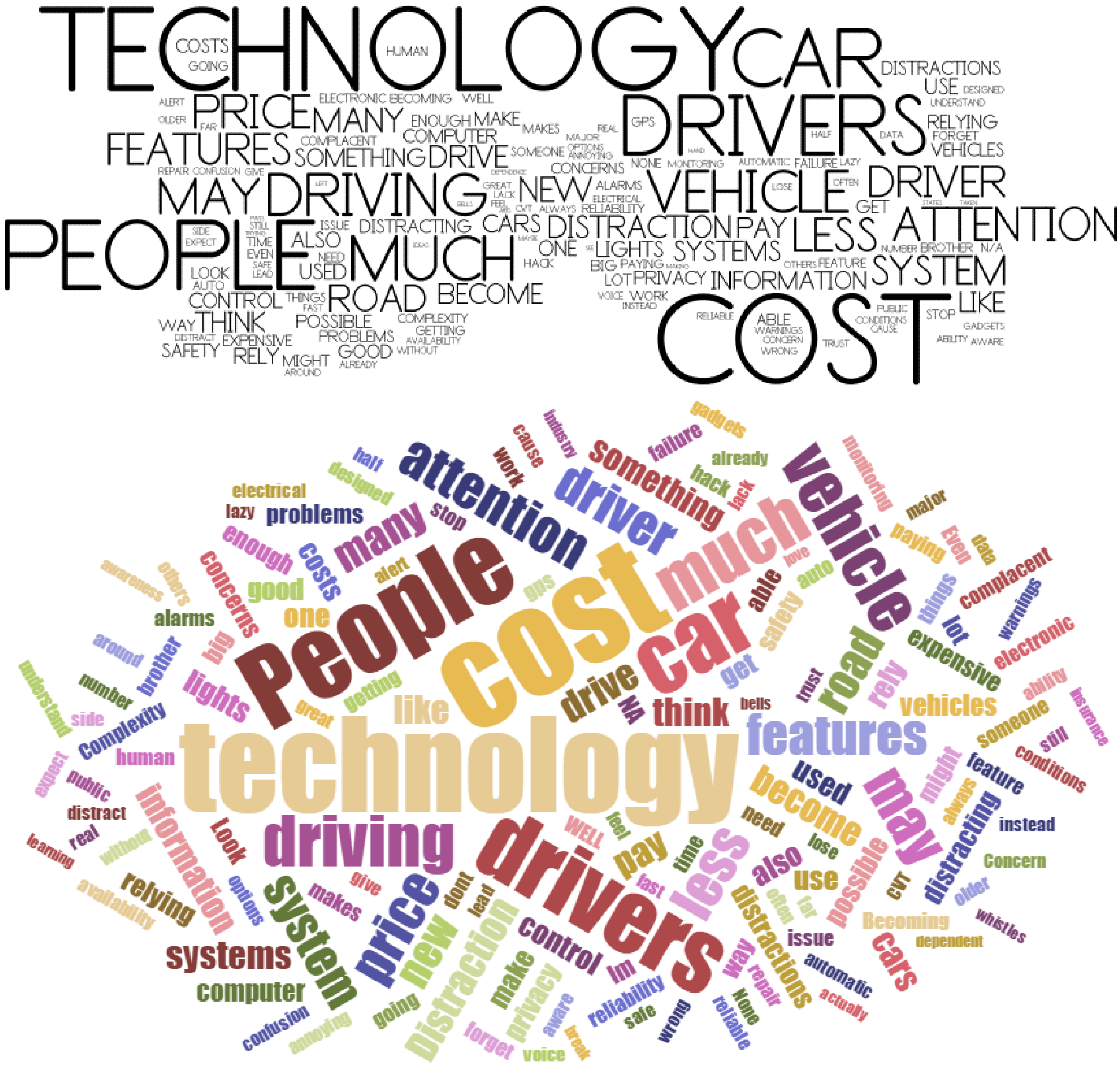


Figure 19. Word cloud for "Constraints/Concerns," CV Knowledge = 2 (limited knowledge).

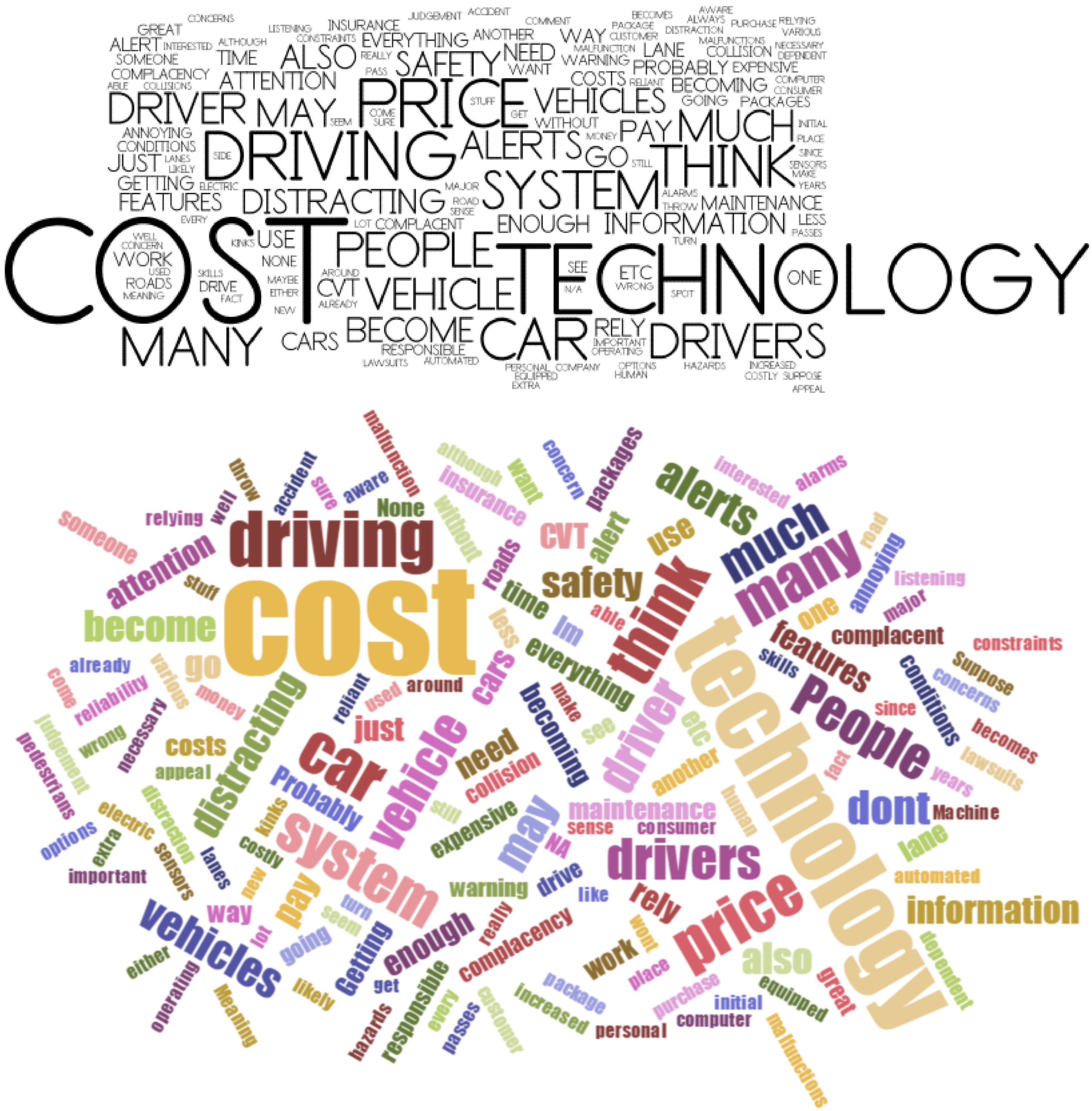


Figure 20. Word cloud for "Constraints/Concerns," CV Knowledge = 1 (no knowledge).

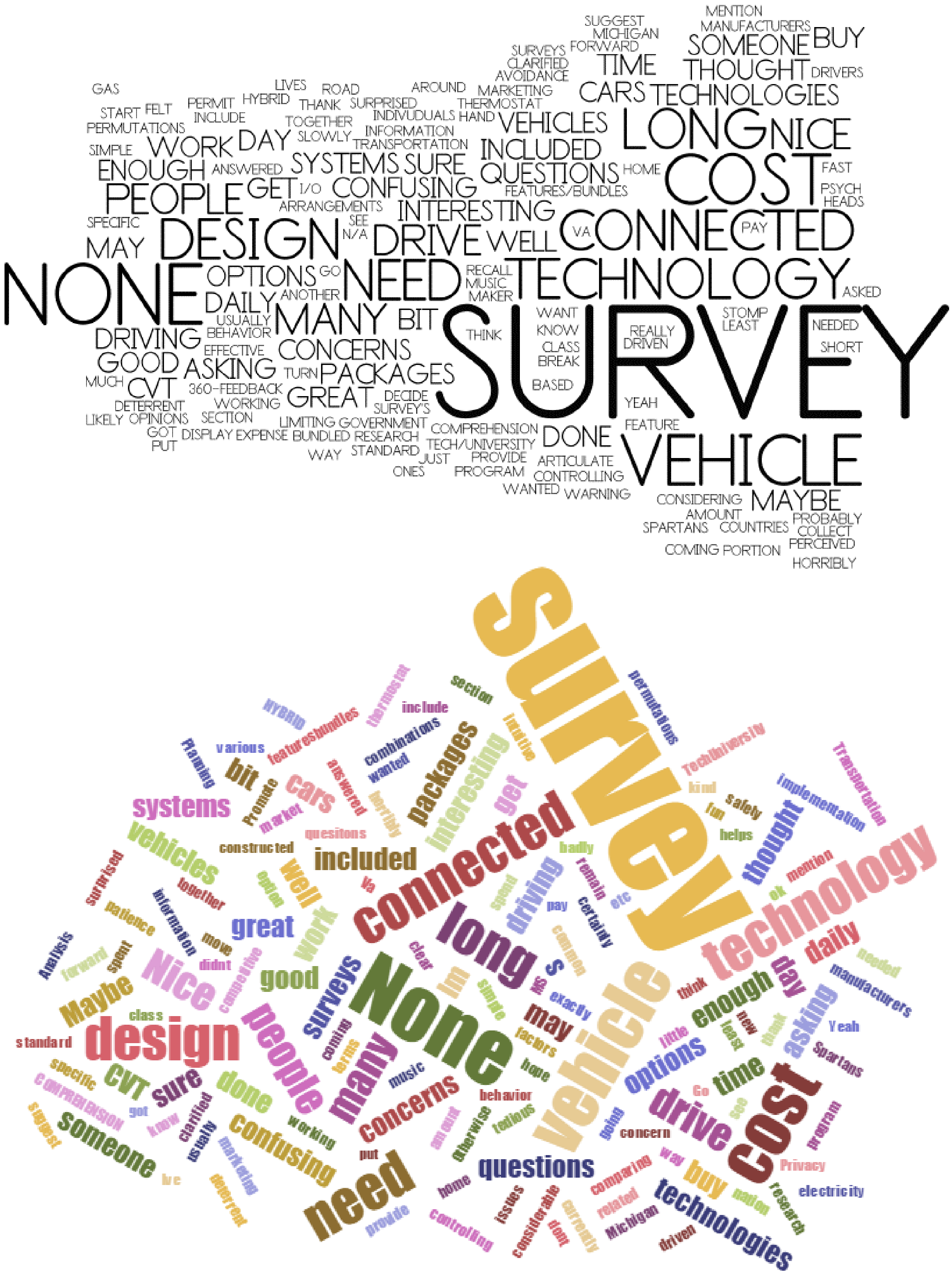


Figure 21. Word cloud for "Comments," CV Knowledge = 3 (knowledgeable).

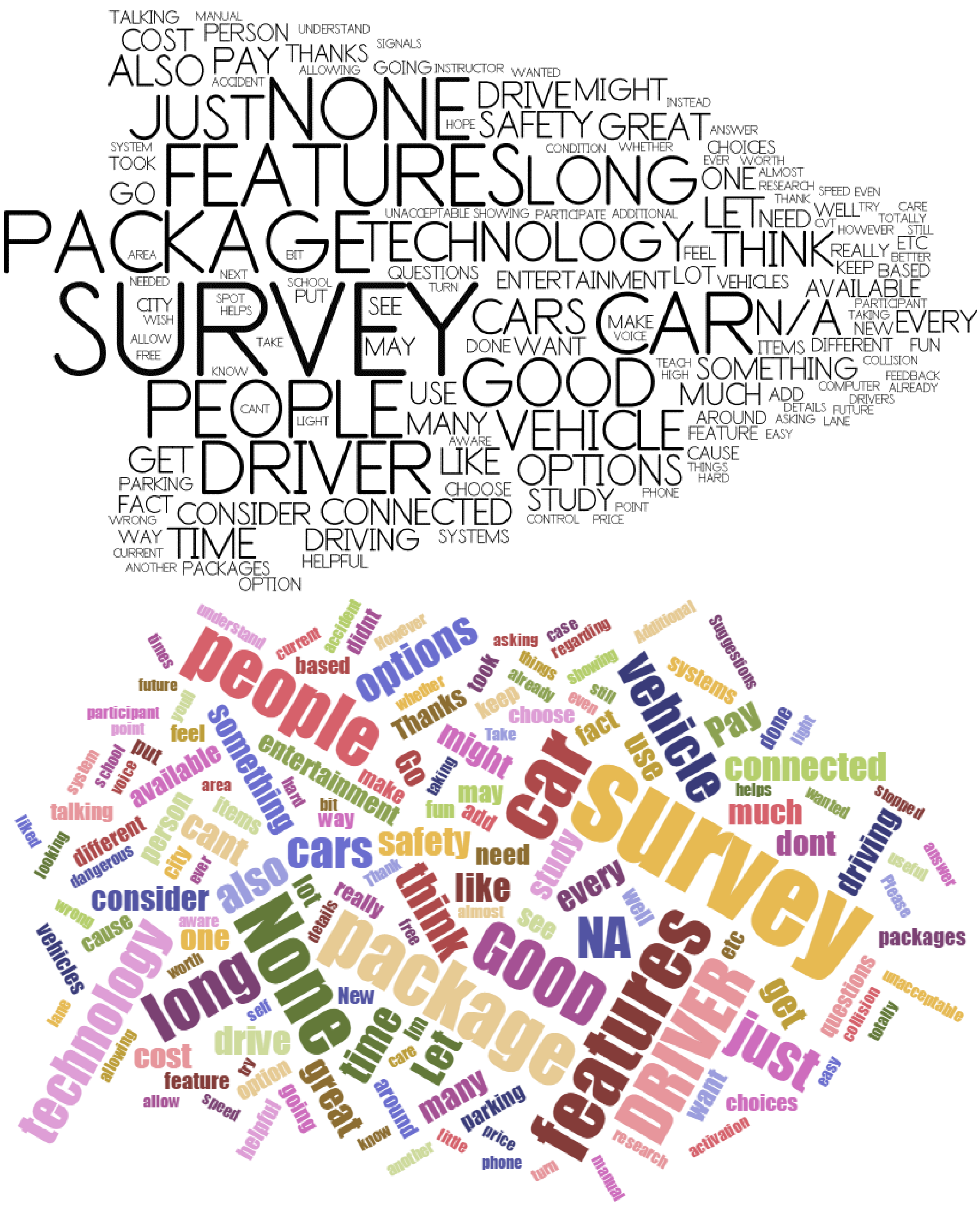


Figure 22. Word cloud for "Comments," CV Knowledge = 2 (limited knowledge).

Figure 23. Word cloud for “Comments,” CV Knowledge = 1 (no knowledge).

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