People's Attitudes Towards Autonomous Vehicles and Transit in Small Urban Areas

Yu Song*
Research Assistant
Department of Civil and Environmental Engineering
Traffic Operations and Safety Laboratory
University of Wisconsin-Madison
1415 Engineering Dr., Madison, WI 53706
Phone: (801) 647-4226, E-mail: yu.song@wisc.edu
*Corresponding Author

Madhav Chitturi
Associate Researcher
Department of Civil and Environmental Engineering
Traffic Operations and Safety Laboratory
University of Wisconsin-Madison
1415 Engineering Dr., Madison, WI 53706
Phone: (608) 890-2439, E-mail: madhav.chitturi@wisc.edu

Chris McCahill
Deputy Director
State Smart Transportation Initiative
University of Wisconsin-Madison
1180 Observatory Drive, Madison, WI 53706
Phone: (608) 262-7797, E-mail: mccahill@ssti.us

David Noyce
Executive Associate Dean, College of Engineering
Arthur F. Hawnn Professor, Department of Civil and Environmental Engineering
Director, Traffic Operations and Safety Laboratory
University of Wisconsin-Madison
1415 Engineering Dr., Madison, WI 53706
Phone: (608) 265-1882, E-mail: danoyce@wisc.edu

Word Count: 6,771 words + 2 tables = 7,271 words

Submitted August 1, 2019

ABSTRACT
Prior survey studies of people's attitudes towards automated vehicles (AVs) mostly took place in large urban areas. No existing studies have assessed the attitudes and opinions of residents in small urban areas. Small urban areas have a great potential in adopting AVs as an integration with transit services. To address this gap in the literature, a survey study of people's attitudes AVs and transit was carried out in a small urban area in Wisconsin, United States. The online questionnaire covered five topics: exposure and opinions about vehicle automation and driving assistance technologies, transit usage, travel habits, attitudes towards technologies, driving, and transit, and demographic information. A total of 217 finished responses were analyzed. Confirmatory factor analysis (CFA) and sentiment analysis were used to quantify attitudes and opinions, which were analyzed using correlation analysis. The results showed that small urban area residents are well-exposed to information about AVs and driving assistance technologies. Small urban area residents generally welcome the development of AV technologies and their application in transit services but are still unsure about the benefits and impacts of these technologies. Over 75% of the respondents are not comfortable with riding a fully automated bus without a human operator, but over 70% are OK with a human operator onboard. Overall, people support transit tend to be positive towards AVs and transit, while people enjoy driving more have more concerns about AVs and transit.

Keywords: autonomous vehicle, transit, attitude, survey, small urban area

INTRODUCTION

Autonomous vehicles (AVs) are expected to be widely available in a decade if not sooner and are expected to become a disruptive force to the existing public transit service framework. A RAND Corporation study in 2014 states that AVs have an advantage in operating costs comparing with mass transit and paratransit, and that substituting those services with AVs will improve social welfare (*1*). Levin and Boyles' model-based quantitative study also predicted that demand for transit will decrease when more people have access to AVs (*2*). Some hold the opinion that while AVs may eliminate the need for conventional transit services, high capacity transit will still be needed on major travel corridors, with AVs serving as a support (*3*-*5*). The increasing private ownership of AVs and infrastructure may change the situation of subsidy and investment for public transit (*6*).

With these potential effects being predicted and discussed, there will be various shapes of transit services in a world with AVs. Transit may integrate with AVs that will serve as feeders or provide "first-mile last-mile" services and use different operational strategies and technologies than the current ones. The public attitude towards and trust in AVs will determine the broader adoption of this disruptive technology in the society.

A survey study was carried out in Eau Claire, Wisconsin. The surveys were online questionnaire surveys asking questions about people's travel habits, opinions about AVs, and their attitudes towards technology, driving, and transit. The purpose of this study is to find out what the general public in small-sized cities in the United States think about AVs and transit, and what are the relationships between their attitudes and their opinions. There are two reasons for this study. First, while there are many existing studies about people's opinions towards AVs that were carried out in large cities and metropolitan areas, few studies have listened to voices from small urban areas, which have very different travel patterns from large urban areas, and will also be an essential part of the future AV market. Second, small urban areas in Wisconsin share a lot of transportation characteristics with most of other small urban areas in United States, which make them good representatives for studying this type of urban areas.

A total of 217 finished responses from Eau Claire were obtained through a survey from April 16 to June 10, 2019 and used for data analysis. In this paper, the survey results are summarized to illustrate the travel patterns of residents of Eau Claire, and their opinions and attitudes about AVs and transit. A general open-ended question in the survey, asking people's general opinion about future of AVs and transit, received many comments. A set of Likert scale questions were asked for people's attitudes towards technology, driving, and transit. Text mining techniques were used to analyze the comments and get quantified sentiments, and confirmatory factor analysis was used to analyze the Likert scale results and get quantified attitudes. A correlation analysis was then carried out to investigate the relationship between the opinion sentiments and the attitudes.

This section is followed by a literature review of recent studies on different models of AV transit services and public opinions towards AVs. The study design and analytical methods will then be elaborated, followed by the survey results, discussion, and conclusions.

LITERATURE REVIEW

There is no clear definition of transit for the future in light of the vehicle automation and other technology developments, but a structure of a future transportation system with publicly shared automated vehicles, and personal automated vehicles can be drawn as the one shown in Figure 1 (*7,8*). Based on this structure, the integration of AVs into transit include the integration of automation technologies into transit services, and the integration of personal or shared AVs as part of transit operations. The most common types of AV integration into transit that were mentioned in recent studies are:

- Shared AV systems, which are similar to a taxi system, ride-hailing systems of transportation network companies (TNCs), or on-demand microtransit systems (*9-13*);
- AVs as first-mile and last-mile services, which feed and pick up passengers to and from transit stations along corridors served by high-capacity transit such as bus rapid transit and urban rail transit (*14-17*); and
- Automated high-capacity transit systems (*18,19*).

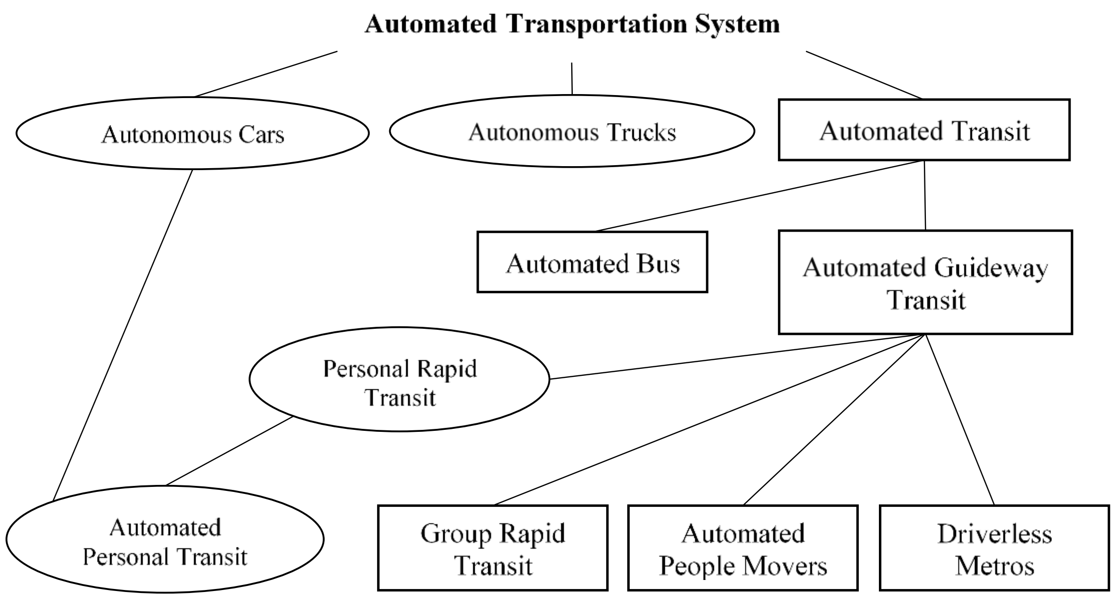


Figure 1 Future automated transportation system (*7,8*)

Existing studies, published within the most recent five years, about the public's attitude and potential consumers' preferences towards AVs, covered privately-owned AVs and their technologies (*20-26*), and multiple types of AV integration with transit (*25-31*).

These studies generally used surveys to collect public opinions towards AV technologies. The studies covered a wide range of countries including France, the U.K., Australia, the U.S., China, India, Japan, and Israel. Overall, there are more people holding positive opinions towards AV technologies, but the general public still have many concerns, about safety when riding an AV, the removal of driver control option from AVs, self-driving commercial vehicles (trucks, buses, and taxis), system failure, and data privacy (*21,22*). Specific preferences for AV technologies are heterogeneous, varying among different groups of people and different geographical locations (*20*,*21*,*22*,*26*). In terms of willingness to pay for AV technologies, the average value that the surveyed people are willing to spend on vehicle automation is quite high ($4,000 to $7,000). Heterogeneity exists in the willingness, the groups of people that are willing to pay very much and very little, made up significant proportions of the surveyed sample (*23*,*25*).

Each of the three types of integration of AV into transit services was covered by some of the existing studies. Most of these studies covered public opinions towards shared AV systems (*25*-*28*), two studies covered AV as first and last mile services (*29*,*30*), and one study covered automated buses (*31*).

Bansal et al. carried out a survey study in the Austin, TX area about public opinions of new vehicle technologies including AV technologies and shared AV systems (*25*). Public opinions about shared AV and willingness to use shared AV were studied using a questionnaire survey. Shared AV (SAV) adoption rates were estimated under three different pricing schemes ($1, $2, and $3 per mile). The survey results indicate that only 15% and 3% of the respondents were willing to use SAVs once a week at a cost of $2 per mile and $3 per mile, respectively. Most respondents are not willing to pay more for a shared AV service than UberX and Lyft currently charge ($1.5 per mile). With $1 per mile, 41% of the respondents will use a shared AV at least once per week.

Haboucha et al. studied the potential user preferences of AVs, with choices including keep using regular cars, buy and shift commute to AVs, and shift to using a shared AV system (*26*). A stated preference questionnaire survey was carried out in Israel, the U.S., and Canada, with 721 complete responses. Questions about respondents' current driving habits, socioeconomic conditions, attitudes towards AVs, and preferences of vehicle travel options were asked in the questionnaire. Regression models were applied to investigate the impact factors of the sample users' choices among the three travel modes. The results indicate that cost is a critical factor affecting users' choices, and that even if the shared AV service were to be completely free, there will still be 25% of individuals not willing to use shared AVs. Individuals who currently have low opinions of transit systems and who never use public transit are less likely to choose shared AVs.

Lavieri et al. also modeled individuals' choices among no interest in using AVs, AV sharing only, AV ownership only, and Both AV sharing and AV ownership, using survey data collected in the Puget Sound, WA, Regional Travel Study (*27*). The models captured factors consumer individual lifestyle preferences including a propensity towards green lifestyle and technology savviness, attitudinal factors about AV technologies, and current use of disruptive transportation services such as carsharing and ride-sourcing services. A generalized heterogeneous data modeling method was used. The results indicate that younger, urban residents who are more educated and technologically savvy are more likely to be early adopters of AV technologies than older, suburban and rural individuals.

Krueger et al. studied the characteristics of users who are likely to adopt shared AV services (*28*). Stated choices survey was carried out among people living in five major metropolitan areas of Australia (Adelaide, Brisbane, Melbourne, Perth, Sydney), from which a sample of 435 people provided data for the mixed logit models in the study. The users were divided into 5 clusters according to their modality styles, which is the behavioral predispositions characterized by a certain travel mode or set of travel modes that an individual habitually uses. The modeling results show that travel cost, travel time and waiting time are critical factors affecting individual's determination of the use of shared AVs and the acceptance of dynamic ride sharing (DRS). Young users are more likely to choose shared AV with DRS than users in other age groups. The individual modality styles (which modes of transportation one usually use daily) are closely related to the selection of shared AVs: current car-sharing users tend to choose shared AV services with DRS; people who travel by car in the reference trips tend to choose shared AV without DRS; and people who use public transit for their reference trips are no more likely to switch to shared AVs than people using other travel modes.

Lu et al. investigated public's opinion about integration of AVs into transit-oriented development (TOD) in Atlanta (*29*). A "topic modeling" method was used to mine 1,540 comments from an online survey about future transportation options. The analysis results indicate that about 40% of the Atlanta residents support or are uncertain about AV technologies and prefer a TOD with AV serving the first and last mile of existing transit services provided by the Metropolitan Atlanta Rapid Transit Authority (MARTA).

Yap et al. studied rail passengers' preferences about AVs as a last mile service for multi-modal train travels (*30*). A stated preference survey was carried out online in the Netherlands among travelers who were over 18 years' old and travel at least twice a month. There were 1,053 completed questionnaires, which were used in the analysis. Three options of last mile travel: AV, transit (bus, tram, and metro) and bicycle were provided in the choice sets. The AV mode has two types, with one type having the travelers drive the vehicles by themselves after getting off from the trains, and the vehicles will then drive themselves back for other travelers to use, which is like a car-sharing service; and the other type having the vehicles driving themselves all the time to pick up and drop off travelers. Mixed logit model was used as the analytical tool. The analysis results show that first class train travelers on average prefer the use of AVs as a last mile service, comparing with other modes including bicycle as well as bus, tram, and metro. In-vehicle time in AVs is experienced more negatively than in-vehicle time in manually driven cars, which indicates that travelers do not yet perceive the theoretical advantage of being able to perform other tasks when the vehicles drive themselves.

Dong et al. evaluated user perception of automated buses, the third type of AV integration into transit (*31*). Similar with the other studies, stated preference survey was conducted to collect user opinion data from the Philadelphia area, and a mix logit model was developed to find out which types of transit users are most willing to ride in driverless buses and whether having a transit employee on board to monitor the vehicle operations and provide customer service matters. The survey collected 891 responses from the University of Pennsylvania's transit pass users. Two-thirds of the respondents were willing to ride a driverless bus, but implied that a transit employee is needed on board to monitor vehicle operations. Among these people, only 13% would agree to ride a bus without an employee on board. Male respondents tend to be more likely to ride a driverless bus than female respondents, and younger respondents (18-34 years' old) are more willing to ride driverless buses than respondents in older age groups.

The existing studies found that in general, there is a good proportion of people that are willing to use AV services, either as a replacement or a complement of transit services. However, there exists heterogeneities in people's preference in how such an AV integrated transit service should work, and how they prefer to use such a service. From the existing studies, it was also found that time and money costs are the most critical factors affecting people's choice between AV services and private travel modes, which is similar with what affects the choice between transit and private travel modes.

STUDY DESIGN AND ANALYTICAL METHODS

An online questionnaire was designed and published to collect data from the City of Eau Claire, WI for two months and statistical analyses were carried out on the data collected.

Questionnaire

The survey was carried out by the University of Wisconsin-Madison in collaboration with the City of Eau Claire, to understand how well the City of Eau Claire's public transportation system serves the community, the role that emerging technologies like automated driving could play, and how to better plan for the future. The questionnaire was designed to collected data on these five aspects:

- Exposure and opinions about vehicle automation and driving assistance technologies
- Transit usage
- Travel habits
- Attitudes towards technologies, driving, and transit
- Demographic information

A list of questions included in the questionnaire are as follows:

Socio-Economic Features

Age
Gender
Occupation
Income
Highest education level
Household family member counts
Number of young children (< 12 years)

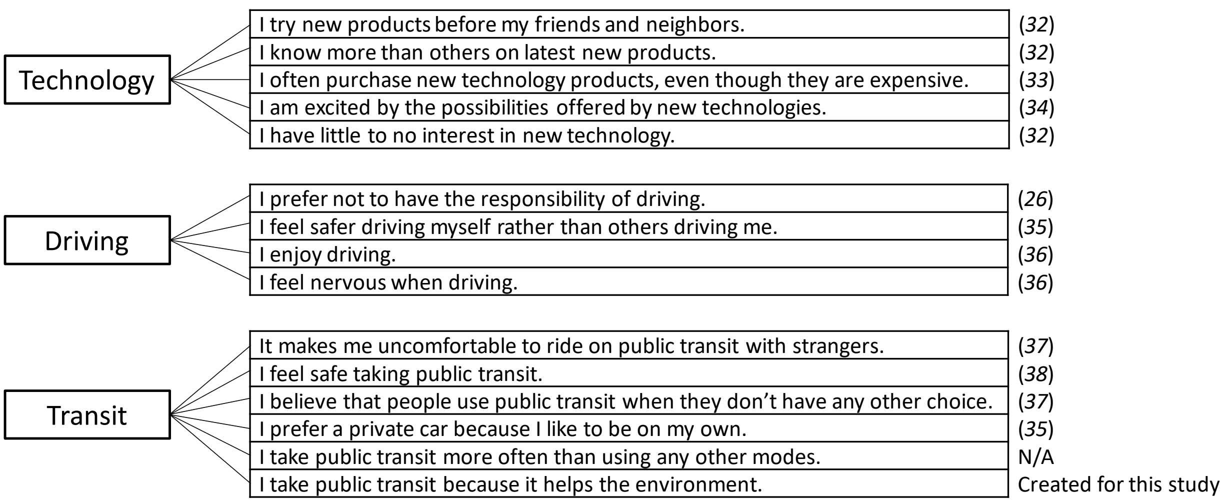
Current Travel Habits

Household car ownership
Commute to work (Y/N)
Number of days in a week commute to work
Commute distance (mi)
Commute time length (min)
Commute primary mode
Other purpose travel primary mode

Heard of AV (Y/N)

Attitudinal

Following the Likert scale statements used by Haboucha et al. for obtaining the attitudinal information regarding the use of shared AV, the questions listed in Figure 2 were included in this part of the survey. These questions were adapted from Haboucha et al.'s study, which are based on questions used and found effective in previous literature (*26*). The questions were revised to accommodate the needs for this study. A Likert scale was used for these statements with five levels, 1 = "strongly agree", 2 = "agree", 3 = "neither agree nor disagree", 4 = "disagree", and 5 = "strongly disagree". In the factor analysis, the scale was converted to ordinal values of 1 to 5. For the statements about technology, a larger value represents more interest in technology. For the statements about driving, a larger value means more love for driving. For the statements about transit, a larger value shows a higher trust or interest in transit.



Note: numbers on the right are sources of these questions.

Figure 2 Attitudinal questions

Confirmatory Factor Analysis

The attitudinal questions followed a defined construct, as shown in Figure 2, in which they were assigned to the three factors, technology, driving, and transit, as measures. For this type of fixed construct about which the a priori knowledge is known or defined, the confirmatory factor analysis (CFA) should be carried out to explore the relationship between the underlying factors and the measured variables. A CFA models that relationship in a form of

$$X = \beta F + \epsilon \quad (1)$$

where, X is a vector of measures, F is a vector of factors, β is the loadings of factors to the measures, and ϵ is the error term.

The measures here are the attitudinal questions, and the underlying factors are the three topics (technologies, driving, and transit), which, in another word, are the attitudes of people towards the three topics. Because the measure-factor construct is defined, the factor analysis method we use is a "confirmatory" one, as in contrast to "exploratory", where the links between measures and factors are unknown before the factor analysis.

The primary estimation procedure used in CFA is maximum likelihood (ML), which assumes normality of the measures. However, Likert scale measures are not continuous and do not necessarily follow normal distributions, for this type of ordinal categorical variables, some other estimation procedure need to be used when conducting CFA. In this study, weighted least squares mean and variance (WLSMV) was used as the estimation procedure. WLSMV is a robust estimation procedure recommended for categorical variables which does not assume normality (*40*). The demanded estimations from CFA are the loadings of the factors onto measures. With the estimations, the overall evaluations for each respondent's attitudes towards the three topics can be calculated. The lavaan package in R was used to carry out the CFA.

Text Mining

In the survey responses, 154 out of 217 included comments under the open-ended question about general opinion on the future of AVs and transit. The comments are mostly not long, with a minimum length of 1 word, a maximum of 118 words, and a mean length of 25 words. As these comments contain important information about people's view about AVs and transit, text mining techniques were used to extract useful information from these comments. Specifically, sentiment analysis (or "opinion mining") was applied on these comments to obtain their positive-negative scores, which is a measure to quantify the respondents' opinions on AVs and transit.

Packages tidytext, tidyr, and dplyr were used in R to conduct the sentiment analysis. The comments were tidied by removing stop words, punctuations, and numbers. Then, the tidied comments were tokenized, which means each word in a tidied comment was pulled out and put on a single row, with its comment ID marked in an adjacent column. The sentiment analysis is a procedure to match sentiment words from a developed lexicon with the words from the comments, then count and summarize the sentiment score for each comment. The AFINN lexicon in R was used for this study. The sentiment score in the AFINN lexicon ranges from -5 to 5, with negative scores indicating negative sentiment and positive scores indicating positive sentiment (*41*). The sentiment score for a comment is the sum of the scores assigned to the matched words in that comment. As the lengths of comment varies, normalized sentiment scores were calculated by dividing the sentiment score for each comment by its tidied length.

SURVEY RESULTS AND DISCUSSION

The online survey was administered from April 16 to June 10, 2019. In total, 290 responses were received, of which, 217 were complete and were analyzed for this study. In summary, the survey results indicate that the respondents are well-exposed to information about AVs and driving assistance technologies. They generally welcome vehicle automation and driving assistance technologies but are still unsure about the future of vehicles equipped with more and more of these technologies. Most of the respondents have access to private vehicles and are satisfied driving them. Transit was not one of the most popular daily traveling modes for these respondents, with the common reasons being "not convenient" and "not flexible" for their needs. While most respondents felt transit was generally safe, they also felt transit is primarily for people without access to other transportation modes. People are uncertain about the safety benefits of adding automation technologies to transit. At the current stage, they still prefer having a human operator even if transit vehicles were automated.

Exposure and opinions about vehicle technologies

In terms of vehicle automation and driving assistance technologies, 94% of the respondents have heard of autonomous vehicles, and 90% of the respondents have a vehicle with one or more driving assistance technologies. The most common technologies the respondents have on their vehicles are cruise control, blind spot detection and warning, and lane departure avoidance. In general, the respondents are happy about those driving assistance technologies. Over three quarters (77%) of the respondents would like more driving assistance technologies on their next car purchase.

Transit usage

About 70% of the respondents never take transit. The average number of times of taking transit in a week, was less than one (0.91). The top three concerns in using transit for the respondents were lack of convenience, lack of flexibility, and poor access. While a considerable proportion of the respondents (40%) are unsure about whether driving assistance technologies will improve the safety for transit vehicles, 30% are positive and 16% are negative about the safety benefits of driving assistance technologies. Over three quarters of the respondents have concerns about taking a fully automated transit vehicle with no human operator onboard, with 48% of the respondents not feeling comfortable riding such a vehicle, and 28% of the respondents unsure about it. However, for the case of a mostly automated transit vehicle with a human operator onboard, most respondents (over 70%) would feel comfortable taking it.

Travel habits

The travel habit questions are about household vehicle ownership, commute pattern, and mode choice. Over 95% of the respondents have one or more personal vehicles in their household, and the average number of household personal vehicles is 2.8. Most of the respondents (over 85%) commute to work, with 66% of the respondents commuting five times per week. Over 60% of the respondents have a commute shorter than 5 miles, and most of the respondents (75%) have commute time of less than 20 minutes. While driving personal vehicle was the first mode choice for 71% of respondents for commuting, it increases to 86% for other trips. Transit was the first choice for 8% of commute trips and 3% of other trips.

Attitudes towards technology, driving, and transit

The attitudinal questions cover three aspects, technology, driving, and transit. The responses to questions about technology imply that the respondents are interested (about 70% agree or strongly agree) and are excited about new technologies (about 70% agree or strongly agree) but are generally rational when making their decisions to spend money on such new technologies. The responses to questions about driving indicated that the respondents are satisfied with driving for their daily travels, and they feel confident and comfortable when driving cars themselves. About 60% of respondents enjoy driving and feel safer driving themselves than when driven by others. From the responses to transit questions, it is found that the respondents prefer using a personal vehicle to taking transit. The respondents generally feel comfortable and safe when taking transit (about 60% agree or strongly agree), but about half of them believe that people only take transit due to lack of access to other modes of transportation. The distributions of responses to questions about the three aspects are illustrated in Figure 3, Figure 4, and Figure 5, respectively.

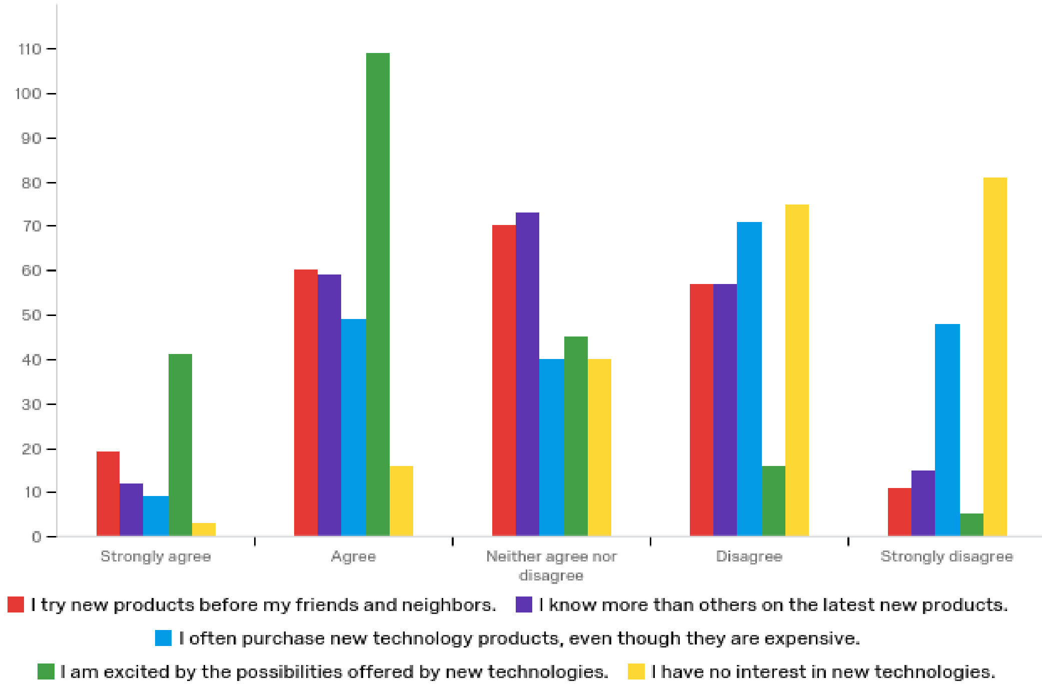


Figure 3 Distributions of responses to questions about technology

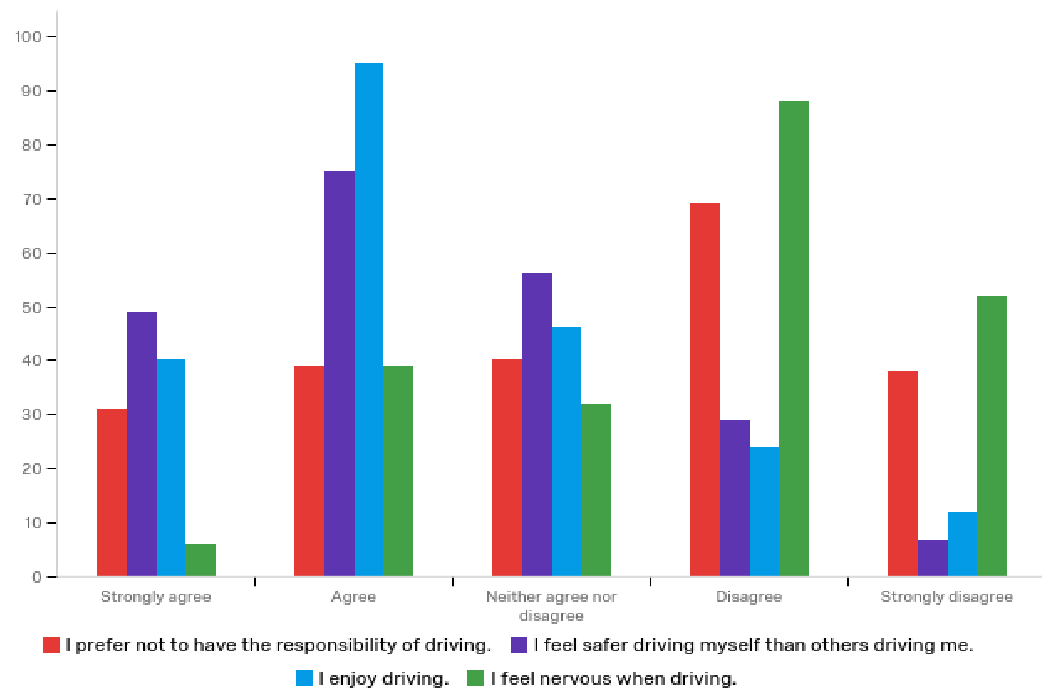


Figure 4 Distributions of responses to questions about driving

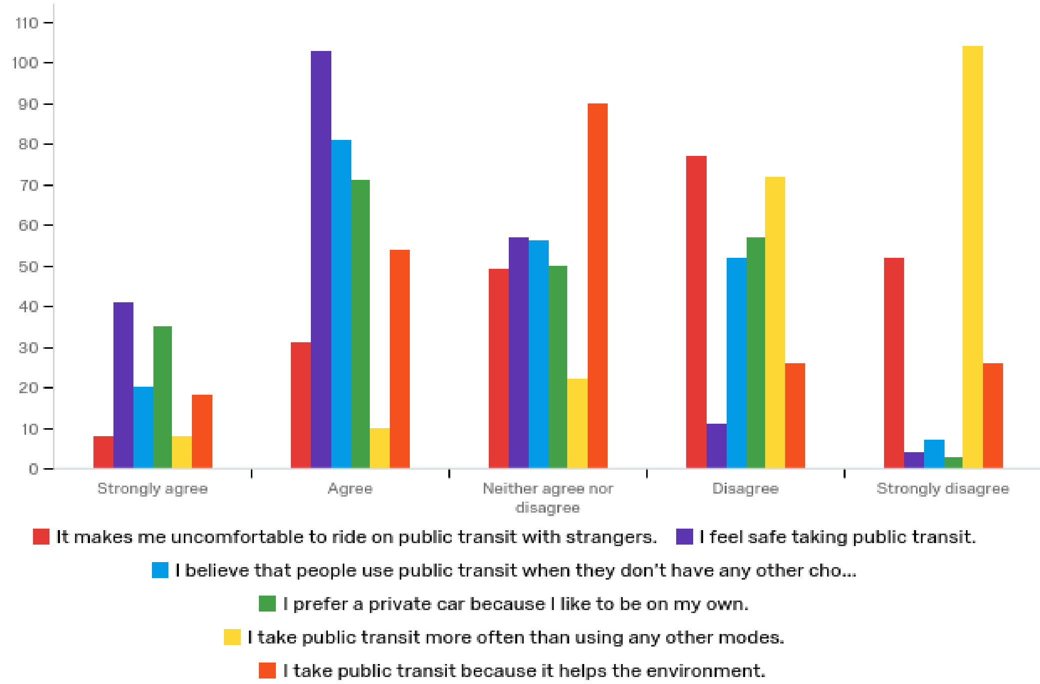


Figure 5 Distributions of responses to questions about transit

Demographic information

The respondents are well distributed across all age groups, with slightly more respondents from the 25-34 age group than the others. There are more respondents from the female gender group (66%). The respondents have a variety of occupations. Most of the respondents (96%) have a valid driver license. Most of the respondents (94%) received some college education or higher. The average household size is 2.48, and 74% of the respondents do not have young kids (< 12 years) in their household. The respondents are mostly from ZIP codes 54701 (53%), 54703 (26%), and 54720 (5%), which cover the central Eau Claire Metro Area.

Correlation between attitudes and opinions

To quantify the attitudes and opinions, CFA and sentiment analysis were used, respectively. The CFA results are summarized in Table 1, where the loadings (β) of factors (F) were estimated, as well as the intercepts (β_0). The model was well fit, according to the fit statistics. All estimates were statistically significant at the 0.05 level. Following this CFA model, the overall evaluations of attitudes towards technology (TE), driving (DR), and transit (TR) were estimated for each response.

The factor loadings reflect how much a factor affects each measure. Each factor loading was standardized to a value between -1 and 1, with negative value meaning a negative effect of the factor on a measure, and a positive value meaning a positive effect of the factor on a measure. For example, the loading of factor “technology” on the measure statement “I try new products before my friends and neighbors” is 0.80. It means that with 1 unit of increase in the interest in technology, the respondent’s Likert rating for the statement will increase 0.8 unit. The intercepts are the base values of the Likert ratings for the statements.

Table 1 Confirmatory factor analysis results

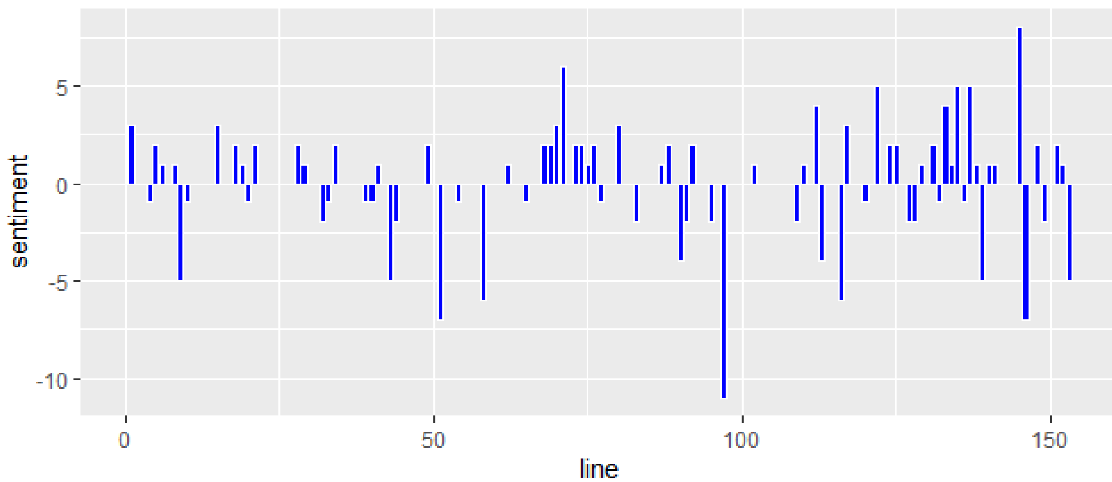
Measure	F	β	β_0
I try new products before my friends and neighbors.	*TE*	0.80	0.36
I know more than others on latest new products.	*TE*	0.80	0.36
I often purchase new technology products, even though they are expensive.	*TE*	0.67	0.55
I am excited by the possibilities offered by new technologies.	*TE*	0.62	0.62
I have little to no interest in new technology.	*TE*	-0.50	0.75
I prefer not to have the responsibility of driving.	*DR*	0.19	0.96
I feel safer driving myself rather than others driving me.	*DR*	-0.56	0.68
I enjoy driving.	*DR*	-0.88	0.23
I feel nervous when driving.	*DR*	0.68	0.53
It makes me uncomfortable to ride on public transit with strangers.	*TR*	0.64	0.59
I feel safe taking public transit.	*TR*	-0.64	0.60
I believe that people use public transit when they don't have any other choice.	*TR*	0.25	0.94
I prefer a private car because I like to be on my own.	*TR*	0.63	0.60
I take public transit more often than using any other modes.	*TR*	-0.42	0.83
I take public transit because it helps the environment.	*TR*	-0.55	0.70
Fit statistics:			
CFI scaled: 0.876; TLI scaled: 0.850; RMSEA scaled: 0.057; SRMR: 0.074			

Note: All estimates are statistically significant at the 0.05 level. F = factor; β = loading; β_0 = intercept.
CFI = confirmatory factor index; TLI = Tucker Lewis index;
RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

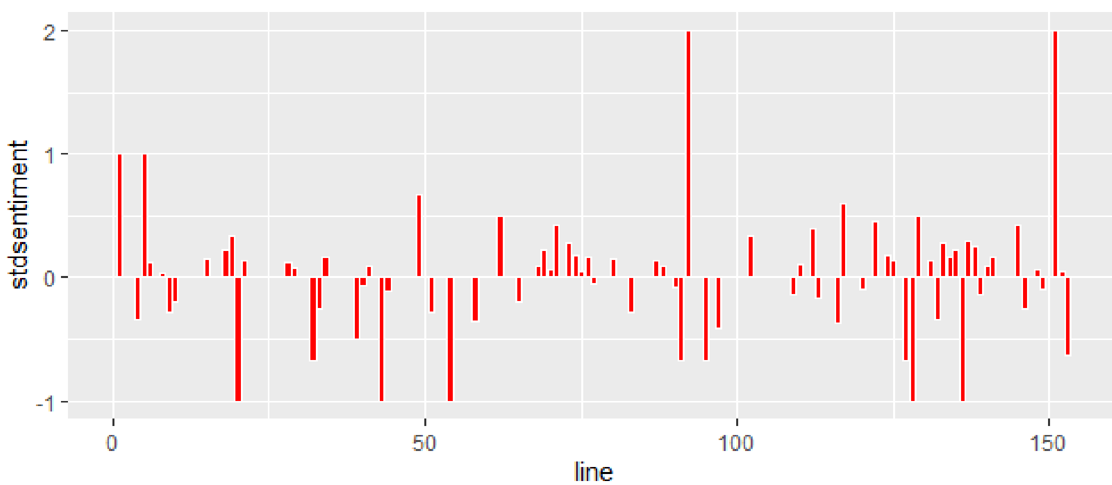
The sentiment analysis results are visualized in Figure 6. Out of the 154 comments, 84 were left after tidying the text and were assigned sentiment scores. The normalized AFINN sentiment score had a maximum value of 2 and a minimum value of -1, with a sample mean of 0.025, a median at 0.068, and a sample standard deviation of 0.514. The frequency distribution of the normalized sentiment score, as shown in Figure 6(c), implies that the general respondents' opinion is positive about the future of AVs and transit, but still uncertain about it.

A correlation analysis was carried out with the estimations of respondents' attitudes towards technology, driving, and transit, as well as respondents' comment sentiment. The correlation analysis results are shown in Existing studies on people's attitudes towards AVs and shared AVs reached similar conclusions regarding the effect of people's technology-savviness (i.e. interest in technology) on their potential use of AVs. Generally, a higher technology-savviness leads to a higher tendency to embrace AV technologies and use shared AVs (*25*-*27*). Existing studies reported mixed conclusions about how people's interest in driving affects their opinions towards AVs. Bansal et al. found that those who drive more were more likely to adopt AVs, and that they were interested more in Level 4 AVs than adding Level 3 automation or using shared AVs (*25*). Lavieri et al. concluded that individuals who currently own vehicles and who have not yet experienced carsharing services are more interested in adopting AVs (*27*). However, Haboucha et al. found that the respondents who enjoy driving are more likely to use their regular car than an AV (*26*). In terms of how people's attitudes towards transit affecting their opinion and use of AVs, the existing studies mostly agreed that people that use transit currently or have positive attitudes about transit are more likely to use shared AVs (*26*, *27*). However, transit users still have concerns about the operational and personal safety for riding an autonomous bus (*31*).

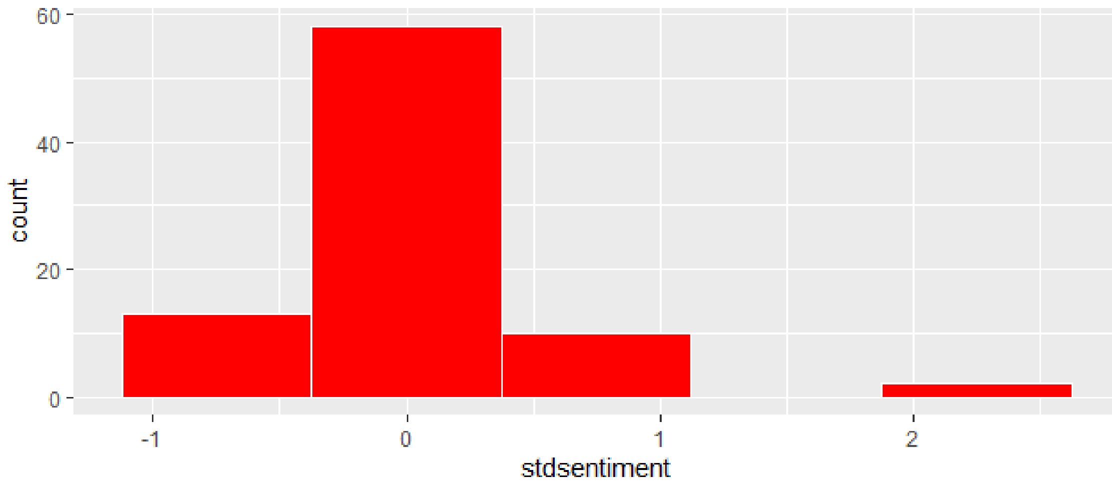
Table *2*. In general, there were no strong correlations found between any pair of these measures. However, the highest correlations were between transit and sentiment (+0.25), driving and technology (+0.15), and driving and sentiment (–0.10). It implies that transit supporters among the respondents generally had a positive view about the future of AVs and transit. Although those respondents who enjoy driving showed more interests in technology than transit supporters, they generally had a slightly negative view about the future of AVs and transit. Interestingly, it was also found that there was not necessarily a clear boundary between support for transit and love for driving, as there was a 0.02 correlation between transit and driving. A few existing studies referenced in the literature review part also evaluated the relationship between people's attitudes and their opinions or potential choices for AV services, but mostly focusing on residents in large urban areas (*25*, *26*, *27*, *31*).



a. Sentiment score of each comment (line)



b. Normalized sentiment (stdsentiment) score of each comment



c. Frequency distribution of normalized sentiment score

Figure 6 Sentiment analysis visualizations

Existing studies on people's attitudes towards AVs and shared AVs reached similar conclusions regarding the effect of people's technology-savviness (i.e. interest in technology) on their potential use of AVs. Generally, a higher technology-savviness leads to a higher tendency to embrace AV technologies and use shared AVs (*25*-*27*). Existing studies reported mixed conclusions about how people's interest in driving affects their opinions towards AVs. Bansal et al. found that those who drive more were more likely to adopt AVs, and that they were interested more in Level 4 AVs than adding Level 3 automation or using shared AVs (*25*). Lavieri et al. concluded that individuals who currently own vehicles and who have not yet experienced carsharing services are more interested in adopting AVs (*27*). However, Haboucha et al. found that the respondents who enjoy driving are more likely to use their regular car than an AV (*26*). In terms of how people's attitudes towards transit affecting their opinion and use of AVs, the existing studies mostly agreed that people that use transit currently or have positive attitudes about transit are more likely to use shared AVs (*26*, *27*). However, transit users still have concerns about the operational and personal safety for riding an autonomous bus (*31*).

Table 2 Correlation analysis results

Measure	*Normalized Sentiment*	*Technology*	*Driving*	*Transit*
Normalized Sentiment	1.00	-0.04	-0.10	0.25
Technology	-0.04	1.00	0.15	0.01
Driving	-0.10	0.15	1.00	0.02
Transit	0.25	0.01	0.02	1.00

CONCLUSIONS

Existing studies about people's attitudes towards AVs have been mostly focused on residents in large urban areas. This study, however, evaluated the attitudes of people living in small urban areas towards AVs and transit. Based on the analysis of 217 questionnaire survey responses, the major findings from this study are as follows.

- Most respondents primarily drive for their daily travels but not all are opposed to transit. Transit was not used frequently due to its lack of convenience and flexibility for the respondents' travel needs.
- Respondents are aware of the concept of AVs and mostly have a positive experience of using driving assistance technologies but are generally uncertain about the safety and reliability of personal and transit vehicles with higher levels of automation in the future.
- Over 75% of the respondents would not be comfortable riding on a fully automated bus without a human operator, but over 70% of the respondents were willing to ride on a fully automated bus with a human operator.
- The correlation analysis shows that transit supporters are positive towards the development of AVs and transit but people who enjoy driving more tend to view AVs and transit negatively.

Comparing with the conclusions drawn from similar existing studies, the findings of this study reveal some common and different features in the attitudes and opinions of people in small urban areas, a different and not yet extensively studied, group of people, under the topic of AVs and transit. People are generally interested but uncertain about the future of vehicle automation. Compared with residents in large urban areas, the travels of small urban area residents are more "car dependent". Over 90% of the surveyed small urban area residents use personal vehicle as their major travel mode. In terms of the attitudes towards driving and transit, small urban area residents, although are more car-dependent than large urban area residents, do not hold negative views towards transit. A clearer boundary may exist between "transit supporters" and "car lovers" in large urban areas. In small urban areas, this study found that technology-savviness does not necessarily mean supportive attitude towards AVs and transit. The interest in driving leads to more concerns about AVs and transit than the interest in transit does.

Based on these findings of this attitudinal study, it can be concluded that in a typical small urban area of the United States, even those who primarily drive are not opposed to transit. They do not use transit frequently because transit services are not flexible and convenient enough to fit their needs. Small urban areas have a great potential in integrating AVs with transit services. AVs, if well-integrated with transit services, seem to be able to satisfy the flexible travel needs of these small urban area residents to some extent. Such an integration may also help change these residents' travel behavior and reduce the overall car ownership. The findings in this study are based on data collected in one small urban area in Wisconsin. A broader data collection from a wide spectrum of small urban areas across the nation is necessary to validate these findings.

ACKNOWLEDGEMENTS

The authors thank the Tommy G. Thompson Center on Public Leadership for sponsoring this research, and the City of Eau Claire for collaborating on the online survey. The work presented in this paper remains the sole responsibility of the authors.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: DN, MC, and CM; data collection: MC, YS, and CM; analysis and interpretation of results: YS; draft manuscript preparation: YS and MC. All authors reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Anderson, J.M., K. Nidhi, K.D. Stanley, P. Sorensen, C. Samaras, and O.A. Oluwatola. Autonomous vehicle technology: A guide for policymakers. Rand Corporation. 2014.

2. Levin, M.W. and S.D. Boyles. Effects of autonomous vehicle ownership on trip, mode, and route choice. Transportation Research Record: Journal of the Transportation Research Board, (2493), 2015, pp.29-38.

3. ITF. Urban Mobility: System Upgrade: How Shared Self-Driving Cars Could Change City Traffic, International Transport Forum and Corporate Partnership Board. 2015. URL: https://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf (Accessed February 2019)

4. TRB. Strategies to Advance Automated and Connected Vehicles, Transportation Research Board. 2017. URL: www.nap.edu/download/24873 (Accessed February 2019)

5. Currie, G. Lies, Damned Lies, AVs, Shared Mobility, and Urban Transit Futures. Journal of Public Transportation, 21(1), 2018, p.3.

6. Grush, B. and J. Niles. How Cities Can Use Autonomous Vehicles to Increase Transit Ridership and Reduce Household Vehicle Ownership. In Canadian Transportation Research Forum 51st Annual Conference-North American Transport Challenges in an Era of Change. Toronto, Ontario, May 1-4, 2016.

7. Liu, R.R., D.J. Fagnant, and W.B. Zhang. Beyond Single Occupancy Vehicles: Automated Transit and Shared Mobility. In Road Vehicle Automation 3 (pp. 259-275). Springer, Cham. 2016.

8. Liu, R. Automated transit: planning, operation, and applications. John Wiley & Sons. 2016.

9. Fagnant, D.J. and K.M. Kockelman. The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios. Transportation Research Part C: Emerging Technologies, 40, 2014, pp.1-13.

10. Fagnant, D.J. and K.M. Kockelman. Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin, Texas. Transportation, 45(1), 2018, pp.143-158.

11. Azevedo, C.L., K. Marczuk, S. Raveau, H. Soh, M. Adnan, K. Basak, H. Loganathan, N. Deshmunkh, D.H. Lee, E. Frazzoli, and M. Ben-Akiva. Microsimulation of demand and supply of autonomous mobility on demand. Transportation Research Record: Journal of the Transportation Research Board, (2564), 2016, pp.21-30.

12. Chen, T.D. and K.M. Kockelman. Management of a shared autonomous electric vehicle fleet: Implications of pricing schemes. Transportation Research Record, 2572(1), 2016, pp.37-46.

13. Farhan, J. and T.D. Chen. Impact of ridesharing on operational efficiency of shared autonomous electric vehicle fleet. Transportation Research Part C: Emerging Technologies, 93, 2018, pp.310-321.

14. Chong, Z.J., B. Qin, T. Bandyopadhyay, T. Wongpiromsarn, E.S. Rankin, E.S., M.H. Ang, E. Frazzoli, D. Rus, D. Hsu, and K.H. Low. Autonomous personal vehicle for the first-and last-mile transportation services. In 2011 IEEE 5th International Conference on Cybernetics and Intelligent Systems (CIS) (pp. 253-260). IEEE. September, 2011.

15. Moorthy, A., R. De Kleine, G. Keoleian, J. Good, and G. Lewis. Shared autonomous vehicles as a sustainable solution to the last mile problem: A case study of ann arbor-detroit area. SAE International Journal of Passenger Cars-Electronic and Electrical Systems, 10(2017-01-1276), 2017, pp.328-336.

16. Shen, Y., H. Zhang, and J. Zhao. Integrating shared autonomous vehicle in public transportation system: A supply-side simulation of the first-mile service in Singapore. Transportation Research Part A: Policy and Practice, 113, 2018, pp.125-136.

17. Scheltes, A. and G.H. de Almeida Correia. Exploring the use of automated vehicles as last mile connection of train trips through an agent-based simulation model: An application to Delft, Netherlands. International Journal of Transportation Science and Technology, 6(1), 2017, pp.28-41.

18. Alessandrini, A., A. Campagna, P. Delle Site, F. Filippi, and L. Persia. Automated vehicles and the rethinking of mobility and cities. Transportation Research Procedia, 5, 2015, pp.145-160.

19. Lazarus, J., S. Shaheen, S.E. Young, D. Fagnant, T. Voege, T., W. Baumgardner, J. Fishelson, and J.S. Lott. Shared Automated Mobility and Public Transport. In Road Vehicle Automation 4 (pp. 141-161). Springer, Cham. 2018.

20. Payre, W., J. Cestac, and P. Delhomme. Intention to use a fully automated car: Attitudes and a priori acceptability. Transportation research part F: traffic psychology and behaviour, 27, 2014, pp.252-263.

21. Schoettle, B. and M. Sivak. A survey of public opinion about autonomous and self-driving vehicles in the US, the UK, and Australia. Report No.: UMTRI-2014-21. University of Michigan Transportation Research Institute. 2014.

22. Schoettle, B. and M. Sivak. Public opinion about self-driving vehicles in China, India, Japan, the US, the UK, and Australia. Report No.: UMTRI-2014-30. University of Michigan Transportation Research Institute. 2014.

23. Daziano, R.A., M. Sarrias, and B. Leard. Are consumers willing to pay to let cars drive for them? Analyzing response to autonomous vehicles. Transportation Research Part C: Emerging Technologies, 78, 2017, pp.150-164.

24. Bansal, P. and K.M. Kockelman. Forecasting Americans’ long-term adoption of connected and autonomous vehicle technologies. Transportation Research Part A: Policy and Practice, 95, 2017, pp.49-63.

25. Bansal, P., K.M. Kockelman, and A. Singh. Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. Transportation Research Part C: Emerging Technologies, 67, 2016, pp.1-14.

26. Haboucha, C.J., R. Ishaq, and Y. Shiftan. User preferences regarding autonomous vehicles. Transportation Research Part C: Emerging Technologies, 78, 2017, pp.37-49.

27. Lavieri, P.S., V.M. Garikapati, C.R. Bhat, R.M. Pendyala, S. Astroza, and F.F. Dias. Modeling individual preferences for ownership and sharing of autonomous vehicle technologies. Transportation Research Record: Journal of the Transportation Research Board, (2665), 2017, pp.1-10.

28. Krueger, R., T.H. Rashidi, and J.M. Rose. Preferences for shared autonomous vehicles. Transportation research part C: emerging technologies, 69, 2016, pp.343-355.

29. Lu, Z., R. Du, E. Dunham-Jones, H. Park, and J. Crittenden. Data-enabled public preferences inform integration of autonomous vehicles with transit-oriented development in Atlanta. Cities, 63, 2017, pp.118-127.

30. Yap, M.D., G. Correia, and B. Van Arem. Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips. Transportation Research Part A: Policy and Practice, 94, 2016, pp.1-16.

31. Dong, X., M. DiScenna, and E. Guerra. Transit user perceptions of driverless buses. Transportation, 46(1), 2019, pp.35-50.

32. Roehrich, G. Consumer innovativeness: Concepts and measurements. Journal of business research, 57(6), 2004, pp.671-677.

33. Jensen, A.F., E. Cherchi, and J. de Dios Ortúzar. A long panel survey to elicit variation in preferences and attitudes in the choice of electric vehicles. Transportation, 41(5), 2014, pp.973-993.

34. Ewing, G. and E. Sarigöllü. Assessing consumer preferences for clean-fuel vehicles: A discrete choice experiment. Journal of public policy & marketing, 19(1), 2000, pp.106-118.

35. Kim, J.H., J.H. Chung, and T. Kim. The effect of psychological traits on mode choice behaviour: An application to a new water transit system in Seoul, Korea. Transportation Planning and Technology, 36(6), 2013, pp.547-566.

36. Devarasetty, P.C., M. Burris, W. Arthur Jr, J. McDonald, and G.J. Muñoz. Can psychological variables help predict the use of priced managed lanes? Transportation Research Part F: Traffic Psychology and Behaviour, 22, 2014, pp.25-38.

37. Rubin, J., Choosing Transit: The Influence of Past Travel Behavior, Attitudes and Habits on Present Choices (Doctoral dissertation, UC Berkeley). 2011.

38. Abou-Zeid, M., M. Ben-Akiva, M. Bierlaire, C. Choudhury, and S. Hess. Attitudes and value of time heterogeneity. Applied Transport Economics-A Management and Policy Perspective. De Boeck Publishing, 2010, pp.523-545.

39. Atasoy, B., A. Glerum, and M. Bierlaire. Attitudes towards mode choice in Switzerland. disP-The Planning Review, 49(2), 2013, pp.101-117.

40. Newsom, J. Practical Approaches to Dealing with Nonnormal and Categorical Variables. Psy 523/623 Structural Equation Modeling, Spring 2018, Lecture Notes, URL: http://web.pdx.edu/~newsomj/semclass/ho_estimate2.pdf (Accessed July 2019).

41. Silge, J. and D. Robinson. Text mining with R: A tidy approach. O'Reilly Media, Inc. 2017.