

User Acceptance of Smart Mobile Resources in Vehicular Technologies Based Upon User Experience and Comfortability: A Research Review

Tasfia Bari M.S. & Dr. Munther Abualkibash
Eastern Michigan University - College of Technology
Michigan, United States of America
Tbari@emich.edu & Mabualki@emich.edu

Abstract

As society evolves to encompass new formats of mobile technologies. It can be observed in everyday resources such as vehicular mobile technologies. This is becoming increasingly evident and observable in resources such as driver assistance software, autonomous vehicles, navigation support, and driver security for accident prevention. To better understand user's willingness to accept and subsequently adopt said automotive technologies, theoretical frameworks and acceptance models such as the Technology Acceptance Model (TAM), Theory of Plan Behavior (TPB), Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) were utilized and reviewed throughout various studies. The outcome suggested that the more generalized, TAM was widely utilized and accepted in terms of predicting user willingness to accept and adopt mobile technology in vehicular settings.

Keywords

Technology, Acceptance, Vehicle, User, Mobility

Introduction

The usage and utilization of technological resources have evolved throughout the last decade. It has expanded in various formats and catered to the needs of users in different walks of life. On a global level, users are expected to adhere to unforeseen changes brought forth by shifting climate and health conditions. Such changes include transporting themselves instead of shared traveling accommodations, and health concerns brought forth by global pandemic precautions due to the implications of COVID-19. The need for sustainable and accessible alternatives to such needs has become increasingly apparent throughout various facets of society (Tam et al. 2021).

Such concerns can be addressed through the product development and growth found in mobile technologies. Whilst often misconstrued or limited in terms of its perception. Mobile technologies have widely expanded in its outreach and overall growth as predicted by the implications of Moore's law (Arpaci 2021). As a result, the need and therefore the dependency upon such technologies has grown to a newfound extent. Users vary in terms of their demographic and each demographic varies in terms of their needs. Based on a user's background, their hierarchy of needs shifts depending upon the structure of their lives and means of living (Chen et al. 2013). For example, users who identify themselves as parents or caretakers may require technological resources that cater to their needs in childcare and or safety of their families (Burnett & Diels, 2018). In contrast to this, younger, more independently inclined users such as young adults or students may require financially resourceful alternatives (Park et al. 2011). Whereas single professional adults who work long hours or have fewer collaborative schedules but multiple tasks or objectives to tend to in their lives may need mobile technological resources that cater to their busy schedules and on-the-go lifestyles (Regan et al. 2018). Regardless of each user's specific needs, the technology itself has grown and shifted to accommodate the diverse, versatile, and continuously expanding needs of its users.

While this concept has primarily been notable in the evolution of computer-based resources, its mobility is now accessible and viable in various formats. This includes technology observed within automotive innovation. As the auto industry has sought to better accommodate its users' needs and preferences, it has taken into consideration the growth of mobile technologies, the accessibility increases that have been brought forth throughout society with such growth, and how efficient it's been (Regan et al. 2018). These changes can be observed in practical measures such as

touch-screen devices implanted within the center console of vehicles established in the 2010's and onwards (Lei et al., 2012). As well as more homogenizing efforts in software such as Tesla technologies, Apple CarPlay and Ford Sync technologies (Kleidermacher, 2005). Such considerations have driven the expansion of these efforts in vehicular technology and its industry with the user in mind, user acceptance and therefore, adoption of such mobile technologies have shifted as well. How can automotive developers predict which specific demographics of users will be inclined to accept these newfound technological efforts? With such inquiries at play, perhaps specific factors within each user demographic can help researchers better grasp the needs of its users before expanding their automotive development efforts.

As technology has been at the forefront of global expansion throughout various industries and sectors throughout society, one key source of impact has been at the basis of this growth (Quinlan, 2023). Educational background plays a key factor in terms of a user's likelihood of technology acceptance as well as its adoption for sustained use (Martin, 2017). The amount and or type of education can often vary in terms of how it is delivered to each learner based on factors that are either within or outside of their control (Rahman et al., 2019). For example, the amount of education an individual has partaken in may influence their acceptance of newfound technologies based on user exposure during their educational experience and their overall comfortability with the technology itself. Educational curriculum has also evolved to actively integrate the use of technology into various subjects and lessons (Regan et al., 2018). This was particularly evident during the sudden need for a shift during the global COVID-19 pandemic (Quinlan, 2023). Therefore, generations of students partaking in education during such integral, societal shifts were obliged to partake in mobile technologies to an extent unlike their predecessors.

Factors that contribute to a user's comfort include the user's age (Burnett & Diels, 2018). The age and therefore the generation into which a user is born may impact their exposure to different technological findings and the integration of those findings throughout society at that time. It also determines the accessibility of technology that is available to them due to the financial costs associated with those resources and the availability of those resources at that time (Bujanov, 2020). Prior to the last thirty years, phones were primarily restricted to physical wires, whereas nowadays they are integrated within wearable technology such as smartwatches or Apple watches as well as vehicular technologies (Ratten & Thaichon, 2021).

1.1 Objectives

This study seeks to understand the benefits in understanding the relationship between factors such as user educational experience and comfortability upon technology acceptance and adoption could further allow researchers and developers within progressive industries such as the automotive industry with insight on how to better understand those who partake in their technologies and the likelihood of adoption and committing to their product.

In the automotive industry, this could indicate long-term customers in terms of brand reliability based on the use and accessibility of the technology they provide. Understanding a user's comfortability with automotive mobile technologies which utilize smart technologies and actively access a user's phone could also help developers understand how much information a user feels comfortable in potentially compromising their information security by divulging information to their vehicle's computer system as well (Kaur et al., 2021).

Overall, a user's access to education, their educational and driving experience and therefore their literary competency is likely to impact and or distinguish their comfortability towards newfound technological efforts such as mobile technology integration within vehicles. Subsequently, this may impact a user's likelihood of accepting such resources long term and further adopting it within their daily lifestyles and for future generations as well.

This review seeks to establish a general understanding of current findings of user perception, acceptance and overall attitude towards the growth and expansion of Advanced Driver Assistance Systems (ADAS) and subsequently the Society of Autonomous Engineers (SAE)'s degrees and standards of autonomy regarding vehicular development. The use of Technology Acceptance Models (TAM) in varying formats of behavioral observation will be utilized to measure user attitudes towards such emerging technologies. The findings based on user attitude could later help automotive manufacturers and developers better cater to the needs of their consumers as they seek to expand their efforts in autonomous, automotive technologies.

2. Literature Review

As technology shifts to surpass the expectations established by society's presumptions and aspirations of the past, it has now achieved goals that were formerly deemed only a concept in terms of its technological structure and output. This is observed in the development efforts of vehicular technology that is becoming increasingly prominent in efforts such as different formats of autonomous vehicles (Bujanov, 2020). As autonomous vehicles have evolved over time, it has built upon their own growth in terms of the amount of autonomy each vehicle has in terms of its "self-driving" capabilities. This study sought to understand a user's perception towards such vehicles and their outcomes suggested that while users are growing in terms of their interest and overall comfortability towards vehicles that are increasingly autonomous, the accessibility of such autonomous vehicles are limited at this time. This further allows researchers and developers to gauge users' expressed interest in their efforts towards the expansion of increasingly autonomous vehicles (Bujanov 2020).

Table 1. Comparing Different Finding on Autonomous Vehicle Acceptance in Accordance with different levels of SAE

Citation:	Autonomous Technology:	User Demographic Observed:	Findings:	Impact:
(Bujanov, 2020)	Vehicles operating at a high autonomous stage of SAE-4. In terms of range of automation.	Drivers aged 18 years and older. In two different global reions.	Parameters and different degrees of technology acceptance were determined through qualitative questionnaire. It was suggested that while the users surveyed did suggest an inclination towards adopting self-automated vehicular technologies, at the time of publication the options available to public consumers were limited.	It was suggested that automotive manufacturers, developers and those seeking to understand consumer behavior and attitude towards the adoption of automated vehicular technologies could greatly benefit from understanding the trends in survey responses acknowledged and variances within question types observed in this study.
(Rejali et al., 2023)	This study sought to establish an understanding of fully automated vehicles (FAV) within different demographics of drivers throughout the country of Iran. To better distinguish which users are intention and willingness to adopt automated vehicular technologies based on technology acceptance principles.	Valid drivers aged 18 years or older residing throughout different regions throughout the country of Iran.	While nearly half of the respondents had little to no prior familiarity with fully automated vehicles, those who were familiar fully automated vehicles operating at SAE-5 suggested willingness to adopt FAVs based on three different technology acceptance models utilized to understand users attitudes towards such vehicles.	By distinguishing specific demographics of drivers within an isolated global region, manufacturers seek to develop a more specified understanding of where to cater expansion of such vehicles. As some users may have been unfamiliar with SAE-5 level FAVs, it may indicate further research and development towards expansion of less intricate levels of automated vehicles such as SAE-3 or SAE-4. The specificity of demographic studied in this publication could also help manufacturers better understand the needs of different geographical climates and infrastructures.
(Rahman et al. 2019)	N/A	Capable drivers were provided with a 10-minute simulation of driving with an advanced driving assistance systems (ADAS) in place and followed up by a survey based on technology	The survey results reinforced the notion technology acceptance models can predict a user's likelihood of acceptance and adoption of newfound technologies such as ADAS.	With ADAS being a significant proponent of SAE, it is important to understand a user's willingness and attitude towards ADAS before seeking to understand their attitudes towards acceptance and adoption of more intricate and autonomous standards of vehicular

		acceptance principles to determine their willingness to adopt ADAS.		automation. This may be beneficial to manufacturers as they advertise such features and different versions of vehicles to their consumers.
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Researchers have also noted that the difference in vehicular autonomy and user acceptance of such technologies can differ based on the theoretical framework in question (Rejali et al. 2023). Predictive measures can be developed through the usage of different variations of the acceptance and adoption models geared towards the usage of technology in vehicles that are considered to be fully automated. It was noted that in terms of accuracy, between the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Unified Theory of Acceptance and Use of Technology (UTAUT). The Theory of Planned Behavior most accurately predicted user perception toward the adoption of fully automated vehicles by users. Similarly, a differing study that observed the impact of automated and electric vehicles in a less sustainable region of the globe recognized that the adoption of electric technologies such as electric vehicles is key in assuring that users become less reliant on perishable resources allowing them to sustain their current lifestyles (Kaur et al.2021). It was noted that a user and therefore, a consumer’s understanding and knowledge of sustainable resources such as electric vehicles impacted their willingness to consider such options as well.

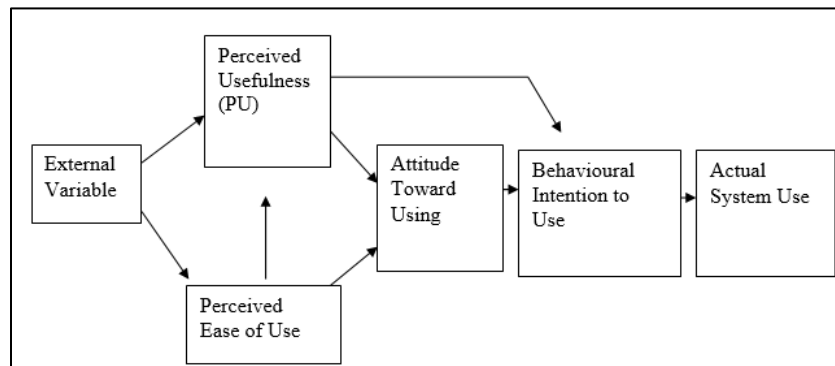


Figure 1. The Technology Acceptance Model (TAM) as established by Davis (1989).
 Reprinted from the Journal of Education and Practice (Wanjala et al. 2015).

Despite the growing interest in the mobile technologies involved in the expansion, the concern for privacy and security of both physical safety and information safety remains at the forefront of many consumers and users (Rahman et al. 2019). Researchers observed the impact of mobile technologies made available to most modern vehicles as a preventative safety measure against road-based accidents. Precautionary technologies such as Advanced Driver Assistance Systems (ADAS) such as OnStar navigation systems can help prevent accidents that are often due to user error (Xing et al. 2020). This may also be noted as driver error or human error regarding the use of automotive technologies (Rojdestvenskiy et al. 2018). When such preventative tools were presented to users, the outcome suggested that utilizing the TAM could provide a relatively close prediction regarding user interest and overall willingness to accept and adopt ADAS technologies. User understanding of such resources also played a role in their acceptance of ADAS technologies and additional, preventative safety measures while driving (Mishra & Kumar, 2021). A vehicle’s level of autonomy was determined following the Self Automated Engineering (SAE) standards (Dyble, 2020).

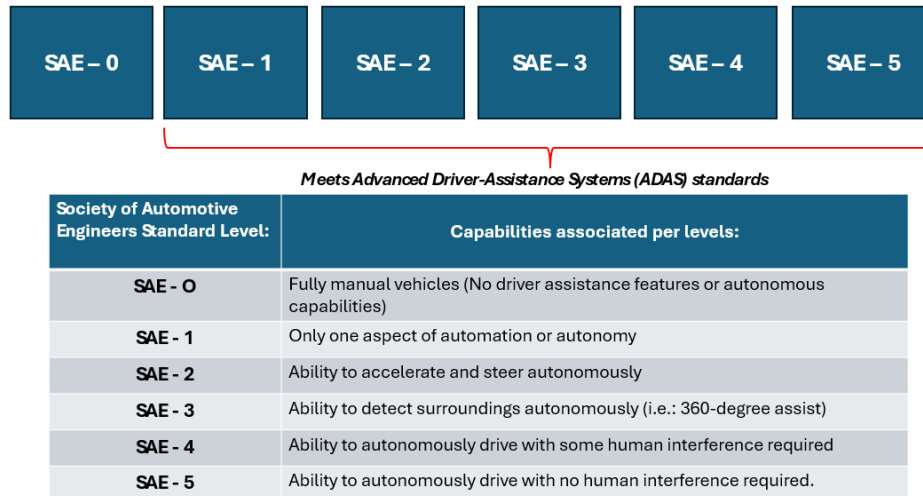


Figure 2. Provides an overview of different degrees of advanced driver assistance in comparison to SAE levels.
Based on (Dyble, 2020)

Other areas of vehicular mobile technologies were observed outside of the vehicle’s entity. For example, mobile applications such as Lyft and Uber, better known as pooling or ride-sharing applications have also brought forth a new expansion of accessibility in terms of vehicular mobile technologies (Wang et al., 2018). Therefore, the TAM was utilized to understand how users intended to utilize ride-sharing applications how likely they were to accept such technologies for daily use, and their comfortability towards such formats of mobile technology based upon their safety concerns in regard to its use.

3. Methods

As vehicular mobile technologies evolve in different formats, user perception of said technologies can be measured through different acceptance models that have been developed to identify user interest and engagement with technologies. Such models include the Technology Acceptance Model (TAM), Theory of Planned behavior (TPB), Perceived usefulness (PU) and Perceived Ease of Use (PEOU). While the observance and use of each varies depending upon the context in which it is utilized, the most widely used model seems to be the Technology Acceptance Model (TAM). It has been utilized in various capacities due to the versatility of its format (Davis & Venkatesh, 2004). For user acceptance, TAM was utilized to understand users’ willingness to be transported in a fully automated vehicle (FVA) and amongst automated vehicles which varied in terms of their automotive capacities (Rejali et al. 2023), (Bujanov, 2020). In contrast to this TPB was utilized in more preemptive measures such as better understanding a user’s intention regarding their acceptance of automotive, and mobile technologies (Hoong et al. 2017).

Due to the research review nature of this study, scholarly search engines were utilized. The search engines were limited to online websites; Google Scholar, SCOPUS, Science.Gov, Elsevier, Web of Science, and IEEE Explore. For identification purposes, research articles were sought by keywords about the research question. Keywords specifically included root terms such as “Technology”, “Mobility”, “User”, and “Vehicle” in addition to supplementary terms such as; “Automation”, “Autonomous Vehicles”, “Technology Adoption”, “Technology Acceptance Model” and “User Acceptance”.

4. Data Collection

Results were reviewed and filtered based initially on relevance to the root key terms, then supplementary key terms and subsequently based upon recency. This hierarchy of search was utilized to ensure that research that had provided preliminary data in the understanding of technology adoption, especially that which pertains to vehicular technology adoption and acceptance as it has continued to evolve in collaborative efforts across the automotive industry. With collaborations varying in terms of ownership and authorization, the usage of multiple search engines allowed for a wider search range. Once identified, the selected articles were reviewed in terms of its contribution to the topic at large. An annotated bibliography was reconciled to organize the research articles to identify key elements and output factors worth noting. All articles were reviewed in adherence to APA 7 format to curate citations.

5. Results and Discussion

Regarding how automotive developers could predict which specific demographics of users will be inclined to accept these newfound technological efforts such as Advanced Driver Assistance Standards (ADAS) and as a result Self-Automated Engineering degrees, research efforts suggest versatility in its outcome and potential. As pre-established theoretical frameworks such as the Technology Acceptance Model, the predictive measures within it such as Perceived Ease of Use and Perceived Usefulness are implemented in new and diverse manners across different sectors of society, it has managed to transition in global shifts in automotive technology as well (Rejali et al. 2023). Evident, in the growth and expansion of automotive resources such as information technology tools that allow users to readily navigate their surrounding regions and consumers' inclination to partake and specifically opt to purchase vehicles based on their compatibility or installation (Harvey et al. 2011).

Based on the demographic of users, factors such as user age, experience, accessibility and budget have all contributed to a user's likelihood of purchasing vehicles equipped with information technology resources (Abdi et al., 2022). The availability of such resources has impacted prospective users to be more inclined to adopt the usage of such vehicles based on their perception of usability and subsequently, the overall acceptance of the autonomous technology itself as it may vary based on intricacy level (Bujanov, 2020). Users with security concerns can anticipate greater considerations for security through the integration of some information technology resources (Rahman et al, 2019). Whereas with the benefits of accessibility brought forth by such resources, further concerns may arise due to the increased autonomy of the vehicle itself (Hoong et al. 2017).

5.1 Numerical Results

Due to the nature of this study, numerical results were not yielded independently for this research review.

5.2 Graphical Results

Due to the nature of this study, numerical results were not yielded independently for this research review. Reprinted graphical results from substantial findings in observed studies can be found in the conclusion section.

5.3 Proposed Improvements

Moving forward, automakers may want to take such potential concerns as well as user's perception of usability and their comfortability in accessing and utilizing these advanced technologies into consideration as it may impact the amount of information users feel inclined to share. Furthermore, it could also influence the pricing of such advanced technology integration into vehicles and its user's willingness to pay additional fees to have that included in their vehicle purchase. A user's perception of value and information assurance could sway their likelihood of adoption and adoption long term. Further insight through first-person feedback could allow automaker developers to better understand the extent to which users feel comfortable in integrating advanced technologies into their consumption interests such as ADAS.

5.4 Validation

Due to the nature of this research format, statistical validation was not required in further evaluating the results. Nevertheless, it should be noted that the majority of the authors reviewed obtained empirical data and utilized meta-analyses to establish multivariate correlations between different factors between users that influenced their likelihood of adoption.

6. Conclusion

Overall, the use of theoretical frameworks has indicated that factors such as user experience and educational background are contributing factors in terms of technology acceptance amongst automotive mobile technologies. It seems that user perception has a multitude of contributing elements, and the perception and weight of those elements vary based upon the user demographic surveyed. While no generalized format of theoretical framework will be ideal for all situations and contexts of users in terms of mobile technology acceptance. It will also vary in terms of user need and within the situation in which the framework was utilized in the past and how it may be adapted for the expansion and generalization efforts of other technologies.

User demographic also continues to play an important role in the likelihood of technological adoption and acceptance (Sugandini et al., 2019). Users who are younger and or more equipped in terms of technology training and experience have displayed greater inclination toward utilizing vehicular technologies that gear users towards further autonomy and engagement (Saariluoma, 2020). While price ranges continue to be contingent upon the manufacturer's make and model options, compared to previous iterations, many are opting to include information technology more accessible within base models of vehicles to draw consumers into investing in their vehicles (Abdi et al., 2022). Additionally, third party applications and tools which are compatible with such vehicles are now available for consumers to purchase independently and add on as they please (Ruddock, 2023). Furthermore, with the ongoing demand and expansion for autonomy throughout different sectors of technology, it is anticipated that it will be a prevalent issue amongst vehicle manufacturers as well (Mishra & Kumar, 2021).

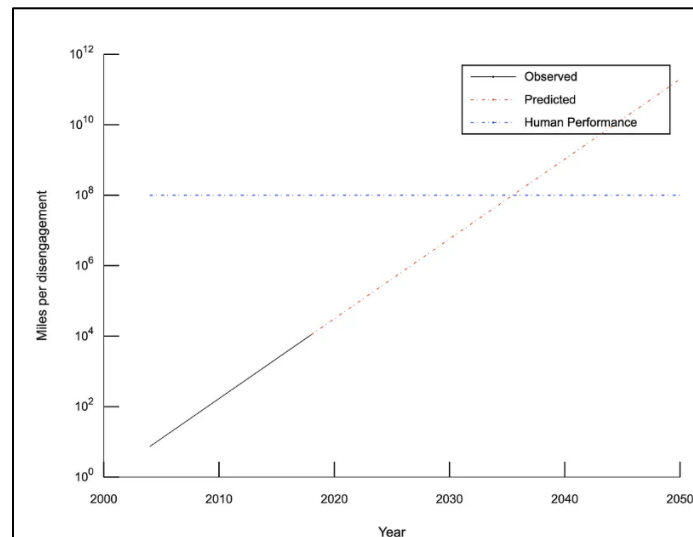


Figure3. Progression of progress between 2004-2018 from the DARPA Challenge Up. Reprinted from Medium.com (Olsen, 2019)

Overall, based on the outcomes presented in the approaches towards validation as seen in studies that observed the impact of user experience, in terms of potential stressors on adoption (Sugandini et al. 2019) and accepting newfound technologies within ongoing familiar sources of transportation (Kleidermacher, 2005), it should be noted that theoretical frameworks such as Technology Acceptance Models which observe the implications of perceived ease of use (Davis & Venkatesh, 2004) and consumer adoption of such technological expansions (Arts et al. 2011) bore similarities in their predictions. Such yields could further substantiate the exercise of such theories as the expansion of mobile technologies are further implemented in the growth of autonomous vehicles and user acceptance of information technologies within their vehicles. Overall, it has also been indicated that both computer technology and autonomous vehicular technology alike will double their performance capabilities every sixteen months (Olsen, 2019). Which can in turn, expand the capabilities of Further research could explore the relationship between the predictions established in theories of user willingness to adopt technology regarding the steady progression of mobile technologies in vehicles identified in consumer feedback and financial growth within that sector.

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Biography

Munther Abualkibash is a professor and graduate coordinator within the Eastern Michigan University College of Technology. His interests and expertise include computer and network security, cloud computing, machine learning and parallel and distributed systems. He received his master's degree from the University of Bridgeport, in Bridgeport, Connecticut. There, he also earned his Ph.D. in computer science and engineering.

Tasfia Bari is a PhD candidate and graduate research assistant in Eastern Michigan University's College of Technology. She earned her Bachelor of Science and Master of Science at Eastern Michigan University in Ypsilanti, Michigan. She has graduate research experience throughout her time in the College of Technology as both a master's and Doctoral candidate. She is currently teaching and working towards earning her PhD while conducting research as a doctoral graduate assistant under the supervision of Dr. Munther Abualkibash.