Fully Autonomous Vehicle

Subjects: Transportation

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Fully autonomous vehicles (AV) would potentially be one of the most disruptive technologies of our time. The extent of the prospective benefits of AVs is strongly linked to how widely they will be accepted and adopted. Monitoring and tracking of individuals' reactions and intentions to use AVs are critical.

Keywords: Fully Autonomous Vehicle ; public perceptions ; transport policy

1. Introduction

Transportation plays a central role in the society and economy [1][2][3], and at the same time, it is a major contributor to the greenhouse gas emissions [4][5]. In recent years, as part of the smart and sustainable transport agenda, autonomous driving solutions are introduced. There is a great promise that fully autonomous on-road vehicles (AVs) yield a variety of societal and environmental benefits, provided that AVs rely on the clean propulsion system. The prospective benefits would likely include facilitated mobility for transport disadvantaged (e.g., elderly, disabled), enhanced traffic efficiency, improved safety, and lower emissions [6][7][8].

Nevertheless, the anticipated benefits of AVs are unlikely to be realized without the broader uptake of AVs, which is linked to public acceptance and adoption intention [9]. In this regard, new business models, such as a sharing economy and a small organization with rapid growth, have appeared. In addition, a sharing economy, whose marginal costs are minimized [10], such as Shared-AVs (SAVs), will become more easily implemented. SAVs could offer on-demand services on non-fixed routes, and they are capable of ridesharing in different ways—i.e., “car sharing with or without ownership, ride-sharing with or without ownership, taxi-service or public transit” ([11], p. 88).

Understanding the likelihood of acceptance and adoption intention of AVs is important as AVs may alter the mobility behavior and lifestyle of users [12]. Nonetheless, since AVs are not publicly available in the traffic system, except for a few trials, predicting the exact travel demand in this context is challenging—e.g., ownership trends, preferred mode choices, vehicle kilometers travelled (VKT). There might also be reactions to the introduction of this technology in the public domain [13]. For instance, Menon et al. [14] found that almost 61.5% of US drivers are unwilling to ride AVs. Thus, it can be anticipated that the major barrier to diffusion of AVs may not originate from the technology side, but rather stem from low public acceptance [15][16][17][18].

While some people are enthusiastic to use AVs, others are not willing to relinquish control of their vehicles, so they are not ready to purchase one [19][20]. To increase AVs’ public acceptance, it is necessary to monitor risk and benefit perceptions closely to find out factors affecting AV acceptance and adoption intention [13][17], since “consumer perceptions will ultimately determine the success or failure of AVs, and potentially drive policy changes as AVs become more common” [21], p.218. To obtain a behaviorally realistic view of AV acceptance and adoption intention, it is critical to explore “unobservable (latent) subjective attitudes and preferences influencing decision-making, along with the observable factors” [22], p.457—e.g., demographic and surrounding built environment characteristics of trip-takers, along with their current mobility behavior characteristics eliciting the decision process [23].

While there have been some review studies revealing insights on AV public acceptance and intention to use [23][24][25][26], a knowledge gap remains. Particularly given the rapid growth in the publications on AVs in the recent years, there is a need for undertaking systematic investigations to generate a cohesive understanding on the factors affecting AV public acceptance and intention to use. A literature search on public perceptions on AVs has revealed that more than half of the literature (n = 42; 52.2%) on the topic was published in 2019. To our knowledge, no systematic literature review work is published yet that includes these latest studies.

2. A Conceptual Framework of Individual Determinant Factors of Behavioral Intention to Use AVs

The prospective impacts of AVs are subject to how likely it is that such technologies will be accepted and used. Henceforth, as underlined by Pettigrew et al. [27] and Sener et al. [28], continuous monitoring and tracking intention to use the emerging AVs as a smart mobility solution is critical. Despite the application of various methodological approaches, data sources, and components, all of the reviewed research studies follow a common objective: “building an evidence-based consensus through continuous measurement of acceptance and potential adoption of AVs” ([28], p.66).

A conceptual framework of individual determinant factors of behavioral intention to use AVs (Figure 1) was developed based on the main technology acceptance theories presented that have good explanatory power for predicting the behavioral intentions and adoption decisions of the potential users. According to this conceptual framework, three main categories of individual determinant factors are comprised of demographic characteristics (i.e., gender, age, education level, employment status, ethnicity, household income, household structure, residential condition), psychological characteristics (i.e., personal innovativeness, awareness of AVs, environmental concerns, facilitating conditions, subjective norms, hedonic motivation, perceived usefulness, perceived ease of use, perceived risks/benefits) as well as mobility behavior characteristics (i.e., vehicle ownership, driving license, exposure to in-vehicle technologies, in-vehicle time, commute mode choice, driving frequency and annual VKT, crash history, trip purpose, daily travel times, mobility impairments).

Figure 1. Conceptual framework of individual determinants of AV public acceptance and intention to use (Source: Authors).

These interrelated factors consequently form either positive (favorable) attitudes or negative (unfavorable) attitudes towards AVs, which influence individuals’ behavioral intention to ride in AVs and adoption/rejection decisions. Moreover, people are likely to decide to adopt different types of AV use—e.g., private ownership, shared ownership or shared use—based on their perceptions and preferences [29] that can be directly affected by individual factors as well. This conceptual framework can be applied to gain a better understanding of the determinants of individuals’ behavioral intention to use AVs to inform urban and transport policymakers, managers, and planners on the influential factors of public acceptance and adoption intention of AVs, which is critical to plan for a healthy AV adoption with minimized societal disruption. Nevertheless, it is expected that AV adoption trends and intention to use will probably change since such innovative services become more commercially available [30], so doing alternate studies and running further stated preference experiments are critical to test prospective market interest.

It is also helpful to increase the predictive power of “technology assessment models” in the context of vehicle automation through finding additional factors affecting AV adoption [31] and their interrelations [23], as well as proficiently capturing the weight of the influential components [26] for more accurate predictions.

3. Conclusions

Developments in artificial intelligence (AI) and smart cities domains have provided opportunities for new urban mobility innovations, where AV technology is a prominent one [32][33][34][35][36]. The culture of open innovation has also accelerated the opportunities for the development of smart mobility solutions [37][38][39][40].

Public perceptions and adoption intentions vary significantly among different socio-demographic cohorts. In the light of the reviewed literature, it is anticipated that early adopters of AVs are likely to be males, young people, highly educated, with higher incomes and larger households, as well as living in a denser neighborhood. Their motivator would be knowledge of AVs, technology savviness, having fewer privacy concerns and positive safety perceptions. However, the current ownership of a vehicle with an advanced driving assistance system, commuting as a driver in carpool arrangements, having automobile collision history and currently commuting longer distances were also found to increase willingness to adopt AVs [8]. In a similar vein, the intention to use AVs differs from one place to another. For instance, AVs are likely to be favorable modes for people in areas with high current crash occurrence since AVs are anticipated to reduce the car insurance rate differences on an age and gender basis, irrespective of future overall insurance rates [41].

Along with the highlighted findings, there is still a need for better understanding the effects of demographic characteristics—e.g., income, education and age—since AVs as first mile/last mile solutions are more likely to target transport-disadvantaged populations such as senior citizens and people with disabilities according to their special needs and preferences [42][43]. This is because, apart from driving, there are restricted mobility choices for senior citizen travelers (including cyclists, drivers, pedestrians, passengers), which may negatively affect people and their families, as well as the community at large [44]. Thus, improved mobility leads to enhanced quality of life and wellbeing outcomes [45].

Further research is also required to focus on the correlation between intention to use AVs and changes in travel behavior, especially for commuting purposes. This is because commuters' value different aspects concerning AVs, which shape their intentions on acceptance and adoption. Additionally, trip takers were found to be more likely to intend to ride fully AVs in monotonous driving conditions, for instance on highways, in traffic congestion [46] or for automatic parking [47]. Perceived benefits of AVs positively affect attitudes towards AVs, while perceived risk is a determinant of negative attitude towards AVs, signifying that if an individual perceives high risk in riding in an AV, there would be less willingness to use and pay for an such innovation, as an individual cannot accrue benefit from an AV; however, there is some variation among different user clusters.

Different policies and incentives are leading to different systemic impacts on promoting wider AV adoption [48][49][50]. Policymakers and planners across several disciplines—e.g., local, state and national governments, and urban and transport planners—could be involved in filling the gap in understanding how AVs impact other domains to introduce communal strategies for broad AV deployment. According to [20], the individual's distrustful views about AVs indicate that their opinions are unlikely to be simply influenced by promotions, although this negativity is mostly based on misconceptions and ignorance and does not have any real knowledge base. Consequently, direct experience of AVs along with education/communication will help change individuals' attitudes towards AVs and convince skeptical clusters of their merits, and thus change people's attitudes towards AVs in a positive way. In this regard, the role of the media in shaping public perceptions should have been taken into consideration.

Furthermore, understanding individual predictors of AV public acceptance and intention to use will inform decision-making in developing policies and actions to make more smart and sustainable mobility and urban systems in cities [51][52][53][54][55][56][57].

References

1. Pitot, M.; Yigitcanlar, T.; Sipe, N.; Evans, R. Land Use & Public Transport Accessibility Index (LUPTAI) tool: The development and pilot application of LUPTAI for the Gold Coast. In ATRF06 Forum Papers; Planning and Transport Research Centre: Melbourne, VIC, Australia, 2006.
2. Yigitcanlar, T.; Dodson, J.; Gleeson, B.; Sipe, N. Travel self-containment in master planned estates: Analysis of recent Australian trends. Urban Policy Res. 2007, 25, 129–149.
3. Kamruzzaman, M.; Yigitcanlar, T.; Yang, J.; Mohamed, M.A. Measures of transport-related social exclusion: A critical review of the literature. Sustainability 2016, 8, 696.
4. Dur, F.; Yigitcanlar, T. Assessing land-use and transport integration via a spatial composite indexing model. Int. J. Environ. Sci. Technol. 2015, 12, 803–816.

5. Sotto, D.; Philippi, A.; Yigitcanlar, T.; Kamruzzaman, M. Aligning urban policy with climate action in the global south: Are Brazilian cities considering climate emergency in local planning practice? Energies 2019, 12, 3418.
6. Milakis, D.; Van Arem, B.; Van Wee, B. Policy and society related implications of automated driving: A review of literature and directions for future research. J. Intell. Transp. Syst. 2017, 21, 324–348.
7. Faisal, A.; Yigitcanlar, T.; Kamruzzaman, M.; Currie, G. Understanding autonomous vehicles: A systematic literature review on capability, impact, planning and policy. J. Transp. Land Use 2019, 12, 45–72.
8. Golbabaei, F.; Yigitcanlar, T.; Bunker, B. The role of shared autonomous vehicle systems in delivering smart urban mobility: A systematic review of the literature. Int. J. Sustain. Transp. 2020.
9. Yigitcanlar, T.; Wilson, M.; Kamruzzaman, M. Disruptive impacts of automated driving systems on the built environment and land use: An urban planner's perspective. J. Open Innov. 2019, 5, 24.
10. Park, H.S. Technology convergence, open innovation, and dynamic economy. J. Open Innov. Technol. Mark. Complex. 2017, 3, 24.
11. Barbour, N.; Menon, N.; Zhang, Y.; Mannering, F. Shared automated vehicles: A statistical analysis of consumer use likelihoods and concerns. Transp. Policy 2019, 80, 86–93.
12. Yigitcanlar, T.; Kamruzzaman, M. Smart cities and mobility: Does the smartness of Australian cities lead to sustainable commuting patterns? J. Urban Technol. 2019, 26, 21–46.
13. Zmud, J.; Sener, I.N.; Wagner, J. Self-Driving Vehicles: Determinants of Adoption and Conditions of Usage. Transp. Res. Rec. 2016, 2565, 57–64.
14. Menon, N.; Pinjari, A.; Zhang, Y.; Zou, L. Consumer perception and intended adoption of autonomous-vehicle technology: Findings from a university population survey. In Proceedings of the Transportation Research Board 95th Annual Meeting, Washington, DC, USA, 10–14 January 2016.
15. Xu, Z.; Zhang, K.; Min, H.; Wang, Z.; Zhao, X.; Liu, P. What drives people to accept automated vehicles? Findings from a field experiment. Transp. Res. Part C Emerg. Technol. 2018, 95, 320–334.
16. Liu, H.; Yang, R.; Wang, L.; Liu, P. Evaluating initial public acceptance of highly and fully autonomous vehicles. Int. J. Hum. Comput. Interact. 2019, 35, 919–931.
17. Zhang, T.; Tao, D.; Qu, X.; Zhang, X.; Lin, R.; Zhang, W. The roles of initial trust and perceived risk in public's acceptance of automated vehicles. Transp. Res. Part C Emerg. Technol. 2019, 98, 207–220.
18. Yigitcanlar, T. Technology and the City: Systems, Applications and Implications; Routledge: New York, NY, USA, 2016.
19. König, M.; Neumayr, L. Users' resistance towards radical innovations: The case of the self-driving car. Transp. Res. Part F Traffic Psychol. Behav. 2017, 44, 42–52.
20. Sanbonmatsu, D.M.; Strayer, D.L.; Yu, Z.; Biondi, F.; Cooper, J.M. Cognitive underpinnings of beliefs and confidence in beliefs about fully automated vehicles. Transp. Res. Part F Traffic Psychol. Behav. 2018, 55, 114–122.
21. Anania, E.C.; Rice, S.; Walters, N.W.; Pierce, M.; Winter, S.R.; Milner, M.N. The effects of positive and negative information on consumers' willingness to ride in a driverless vehicle. Transp. Policy 2018, 72, 218–224.
22. Nazari, F.; Noruzoliaee, M.; Mohammadian, A.K. Shared versus private mobility: Modeling public interest in autonomous vehicles accounting for latent attitudes. Transp. Res. Part C Emerg. Technol. 2018, 97, 456–477.
23. Gkartzonikas, C.; Gkritza, K. What have we learned? A review of stated preference and choice studies on autonomous vehicles. Transp. Res. Part C Emerg. Technol. 2019, 98, 323–337.
24. Becker, F.; Axhausen, K.W. Literature review on surveys investigating the acceptance of automated vehicles. Transportation 2017, 44, 1293–1306.
25. Johnsen, A.; Strand, N.; Andersson, J. Literature Review on the Acceptance and Road Safety, Ethical, Legal, Social and Economic Implications of Automated Vehicles: Deliverable 2.1 from the EU-H2020-Project BRAVE-BRidging the Gabs for the Adoption of Automated Vehicles; Institut für Empirische Soziologie an der Universität Erlangen-Nürnberg: Nürnberg, Germany, 2018.
26. Nordhoff, S.; Kyriakidis, M.; Van Arem, B.; Happee, R. A multi-level model on automated vehicle acceptance (MAVA): A review-based study. Theor. Issues Ergon. Sci. 2019, 20, 682–710.
27. Pettigrew, S.; Worrall, C.; Talati, Z.; Fritschi, L.; Norman, R. Dimensions of attitudes to autonomous vehicles. Urban Plan. Transp. Res. 2019, 7, 19–33.
28. Sener, I.N.; Zmud, J.; Williams, T. Measures of baseline intent to use automated vehicles: A case study of Texas cities. Transp. Res. Part F Traffic Psychol. Behav. 2019, 62, 66–77.

29. Acheampong, R.A.; Cugurullo, F.; Dusparic, I.; Guériau, M. An Examination of User Adoption Behavior of Autonomous Vehicles and Urban Sustainability Implications. Transp. Res. Proc. 2019, 41, 187–190.
30. Sweet, M.N.; Laidlaw, K. No longer in the driver's seat: How do affective motivations impact consumer interest in automated vehicles? Transportation 2019, 1–34.
31. Panagiotopoulos, I.; Dimitrakopoulos, G. An empirical investigation on consumers' intentions towards autonomous driving. Transp. Res. Part C Emerg. Technol. 2018, 95, 773–784.
32. Yigitcanlar, T.; Butler, L.; Windle, E.; DeSouza, K.C.; Mehmood, R.; Corchado, J.M. Can Building "Artificially Intelligent Cities" Safeguard Humanity from Natural Disasters, Pandemics, and Other Catastrophes? An Urban Scholar's Perspective. Sensors 2020, 20, 2988.
33. Yun, J.J.; Lee, D.; Ahn, H.; Park, K.; Yigitcanlar, T. Not Deep Learning but Autonomous Learning of Open Innovation for Sustainable Artificial Intelligence. Sustainability 2016, 8, 797. [Google Scholar] [CrossRef]
34. Yigitcanlar, T.; Kankanamge, N.; Vella, K. How Are Smart City Concepts and Technologies Perceived and Utilized? A Systematic Geo-Twitter Analysis of Smart Cities in Australia. J. Urban Technol. 2020, 1–20.
35. Yigitcanlar, T.; Han, H.; Kamruzzaman, M.; Ioppolo, G.; Sabatini-Marques, J. The making of smart cities: Are Songdo, Masdar, Amsterdam, San Francisco and Brisbane the best we could build? Land Use Policy 2019, 88, 104187.
36. Chang, D.L.; Sabatini-Marques, J.; Da Costa, E.M.; Selig, P.M.; Yigitcanlar, T. Knowledge-based, smart and sustainable cities: A provocation for a conceptual framework. J. Open Innov. Technol. Mark. Complex. 2018, 4, 5–17.
37. Yun, J.J.; Zhao, X.; Jung, K.; Yigitcanlar, T. The Culture for Open Innovation Dynamics. Sustainability 2020, 12, 5076.
38. Yun, J.J.; Jung, K.; Yigitcanlar, T.; Jung, K. Open Innovation of James Watt and Steve Jobs: Insights for Sustainability of Economic Growth. Sustainability 2018, 10, 1553.
39. Yun, J.J.; Won, D.; Jeong, E.; Park, K.; Lee, D.; Yigitcanlar, T. Dismantling of the Inverted U-Curve of Open Innovation. Sustainability 2017, 9, 1423.
40. Yun, J.J.; Zhao, X.; Yigitcanlar, T.; Lee, D.; Ahn, H. Architectural Design and Open Innovation Symbiosis: Insights from Research Campuses, Manufacturing Systems, and Innovation Districts. Sustainability 2018, 10, 4495.
41. Hudson, J.; Orviska, M.; Hunady, J. People's attitudes to autonomous vehicles. Transp. Res. Part A Policy Pract. 2019, 121, 164–176.
42. Madigan, R.; Romano, R.; Dziennus, M.; Graindorge, T.; Ortega, E.; Graindorge, M.; Merat, N. Acceptance of Automated Road Transport Systems (ARTS): An Adaptation of the UTAUT Model. Transp. Res. Proc. 2016, 14, 2217–2226.
43. Lee, Y.-C.; Mirman, J.H. Parents' perspectives on using autonomous vehicles to enhance children's mobility. Transp. Res. Part C Emerg. Technol. 2018, 96, 415–431.
44. Hassan, H.M.; Ferguson, M.R.; Razavi, S.; Vrkljan, B. Factors That Influence Older Canadians' Preferences for using Autonomous Vehicle Technology: A Structural Equation Analysis. Transp. Res. Rec. J. Transp. Res. Board 2019, 2673, 469–480.
45. Sun, Y.; Olaru, D.; Smith, B.; Greaves, S.; Collins, A. Road to autonomous vehicles in Australia: An exploratory literature review. Road & Transport. Res. J. Aust. N. Z. Res. Pract. 2017, 26, 34.
46. Bansal, P.; Kockelman, K.M.; Singh, A. Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. Transp. Res. Part C Emerg. Technol. 2016, 67, 1–4.
47. Payre, W.; Cestac, J.; Delhomme, P. Intention to use a fully automated car: Attitudes and a priori acceptability. Transp. Res. Part F Traffic Psychol. Behav. 2014, 27, 252–263.
48. Butler, L.; Yigitcanlar, T.; Paz, A. How Can Smart Mobility Innovations Alleviate Transportation Disadvantage? Assembling a Conceptual Framework through a Systematic Review. Appl. Sci. 2020, 10, 6306.
49. Mahbub, P.; Goonetilleke, A.; Ayoko, G.A.; Egodawatta, P.; Yigitcanlar, T. Analysis of build-up of heavy metals and volatile organics on urban roads in gold coast, Australia. Water Sci. Technol. 2011, 63, 2077–2085.
50. Fraedrich, E.-M.; Heinrichs, D.; Bahamonde-Birke, F.J.; Cyganski, R. Autonomous driving, the built environment and policy implications. Transp. Res. Part A Policy Pract. 2019, 122, 162–172.
51. Yigitcanlar, T. Kamruzzaman Planning, Development and Management of Sustainable Cities: A Commentary from the Guest Editors. Sustainability 2015, 7, 14677–14688.
52. Yigitcanlar, T.; Han, H. Kamruzzaman Approaches, Advances, and Applications in the Sustainable Development of Smart Cities: A Commentary from the Guest Editors. Energies 2019, 12, 4554.

53. Arbolino, R.; De Simone, L.; Carlucci, F.; Yigitcanlar, T.; Ioppolo, G. Towards a sustainable industrial ecology: Implementation of a novel approach in the performance evaluation of Italian regions. J. Clean. Prod. 2018, 178, 220–236.
54. Yigitcanlar, T. Rethinking Sustainable Development: Urban Management, Engineering, and Design; IGI Global: Hersey, PA, USA, 2010.
55. Yigitcanlar, T. Sustainable Urban and Regional Infrastructure Development: Technologies, Applications and Management; IGI Global: Hersey, PA, USA, 2010.
56. Yun, J.J.; Yigitcanlar, T. Open Innovation in Value Chain for Sustainability of Firms. Sustainability 2017, 9, 811.
57. Yigitcanlar, T. Planning for smart urban ecosystems: Information technology applications for capacity building in environmental decision making. Theor. Empir. Res. Urban Manag. 2009, 4, 5–21.
